

METALLURGIC DEPART - GILT EDGE
PROCESS WATER TREATMENT & DISPOSAL

MEMORANDUM

TO: Rod MacLeod
FROM: Jim Thompson
DATE: March 22, 1994
RE: RO Unit

Rod, there's been some talk about not buying the RO Unit and sending it back. I would like to caution you on this. Just because the surge pond is getting low, we are still going to get our average 5 mil. gallons of rain this spring (March - June). I'd like also to talk about the 2 pits (Sunday and Dakota Maid).

Our best guess is that the Dakota Maid pit has around 6-9 mil. gallons of pH³ water in it and the Sunday pit has around 30 mil. gallons of pH³ water, plus we are adding about 150 gpm every day from Ruby. That alone is 4.1 months of run time for the RO, plus our 5 mil. in the surge pond, which is 3 months of run time that totals 7 months. So in October 1994 we should be okay. But then comes cells 1-4 off-loading. Cells 1-4 have about 10 mil. gallons of solution tied up in them. Since cells 1-4 are 90 feet high, we will have to off-load them in 2 or 3 lifts. The way I see it, Rod, we will turn off cells 1 and 2 first so they can off-load half of the first lift. While they are off-loading that first half, there will be 432,000 gallons a day going to the surge pond. It will take around 6½ days to off-load half of the first lift that equals 2.8 mil. gallons in the surge pond. Then the next half of the top lift and you now have 5.6 mil. gallons in the surge pond.

Now none of cells 1-4 are under leach and we are going to have complete drain down. I should be able to off-load some of that 10 mil. gallons, but I don't know how much. The RO is going to have to be run the whole time. By the time cells 1-4 are off-loaded, it is now November 1994, our surge pond is full again and it's slow crushing. Now with the new ore on the leach pad and the RO running cell 6 and 7 are going to be off-loaded. Spring snow melt and rain is coming and we start all over again in the spring of 1995.

In the winter of 1995 and spring of 1996 we now have a new pad, we have made our old pad bigger and we have 2 new ponds. As we know, 1 inch of rain equals half a mil. in the surge pond. Now with the new pads and ponds 1 inch of rain equals 1,082,568 mil. gallons.

Rod, we would have to put a building over it to run year-round.

JT:sm

cc Dale Shay, BMC
Lance Hubbard, BMC
Troy Fierro, BMC

M E M O R A N D U M

TO: Martin Quick

FROM: Rod MacLeod

DATE: August 2, 1994

RE: Gilt Edge Strategic Planning - Pad Drain Down

Martin, the following are problems and issues we are wrestling with in our attempt to provide options. Please call to discuss after reviewing.

FACTS

- According to process personnel, cells 1-4 are within two loads of peroxide from being neutralized at an estimated cost of \$31,000.

- To date we have consumed 11 loads of peroxide to neutralize cells 1-4, or spent approximately \$188,300.

- Drain down of cells 1-4 prior to being fully neutralized will require that we treat an additional 12 million gallons of process solution before the spent ore is off-loaded (total of 24 million gallons for just 1-4).

- Depending upon when we receive permits to mine Anchor Hill we could delay placement of Anchor Hill ore and/or sulphide stock pile ore onto the existing leach pad due to cells 1-4 neutralization and R.O. treatment of process solution.

- Our best estimate of the solution held in cells 1-4 and cells 5-7 is 18 million gallons. Based on past experience we will receive a minimum of 5 million additional gallons to the process circuit due to spring runoff and precipitation. This brings the total process solution that will need to be treated to 23 million gallons.

- The reverse osmosis unit, as an average, will treat approximately 1,500,000 gallons of process solution per month. It will treat approximately 7,000,000 gallons of pit water per month.

The current amount of water in the Sunday Pit, to be treated, is estimated to be 60 million gallons. Treatment and discharge of this water will be one of the key components required to maintain Ruby Gulch and Strawberry Creek NPDES compliance. Whether treatment is achieved with a reverse osmosis unit or a water treatment plant is yet to be determined. Current thinking is that the Ruby Gulch Water Treatment Plant would better serve the site if it were located on top of the hill where water could be pumped from Ruby Gulch, the Sunday Pit, Strawberry Creek, or Hoodo Gulch to the treatment plant.

Discharge of treated water into Strawberry Creek cannot begin until the beaver dam tailings have been removed. At present most flow from Strawberry Creek and Cabin Creek is being diverted around the beaver dams. In spite of that we are still encountering enough seepage into work areas to cause concern and require some modification of our approach to the work.

If we decide to defer acquisition and construction of a water treatment plant in 1994 it will make it even more critical to treat and discharge Sunday Pit water; install a more efficient pumping system from Ruby Gulch to the Sunday Pit; and allow for pumping from Strawberry Creek or Hoodo Gulch to the Sunday Pit. The bottom line is we need to better equip ourselves for maintaining compliance at two points beginning November 1, 1994.

To treat process solution through the R.O. Unit, recirculation needs to continue until there is no more than 5 million gallons in the process circuit. The plant will need to operate as long as we are treating process solution so it can be put through the plant clarifiers.

The following are time estimates to treat both process solution and Sunday Pit water with a reverse osmosis unit, based on the preceding information:

Process Solution

Current amount in circuit	18,000,000 gallons
1995 Spring runoff	<u>5,000,000 gallons</u>
Total	23,000,000 gallons

Average Treatment Rate
Time to treat

1,500,000 gallons/month	
<u>23,000,000 gallons</u>	= 15 months
1,500,000 gallons/month	

Strategic Planning

Page 2

August 2, 1994
Rod MacLeod

Pit Water

Current amount in pit	60,000,000 gallons
Spring runoff additions	<u>19,000,000 gallons</u>
(*Based only on amount pumped from Ruby to pit in 1993)	
Total	79,000,000 gallons

Estimated Treatment Rate

7,000,000 gallons/month

Time to Treat

12 months

RM:pf

CORRESP1STRATPLA.RJM

Strategic Planning**Page 3****August 2, 1994
Rod MacLeod**

LEACHING PLANT - WATER BAL

CARBON → 350 GPM
Gull Plant - includes stripping circuit.
4500 / mth lease
9,750 / setup
+ 4K Carbon — variable carbon

UNKNOWN(S) / PROBLEM(S)

- Cu in system 700 - 800 ppm - Needs to be ~~in~~ 10 ppm
- Treating 13 - 15 million gallons of process solution to get rid of Cu.

High Cu = No Au
If Cu < 10 ppm then
with today's grade (Au @ .008) and ~~barren~~ barren
@ .002 = .006 Recovered

$$\begin{aligned} & 2140 \text{ Tons Solution/day} \times .006 \text{ opt} \\ & = 12.6 \text{ oz/day} \times \checkmark 30 \text{ days/month} \\ & = 378 \text{ oz} \times 370 \text{ / oz} = 139,860 \text{ / month} \end{aligned}$$

Assumes Recirc and ability to remove Cu

$$\begin{array}{r} 139,860 \\ - 4,500 \\ \hline 135,360 \end{array} \text{ - with plant rental}$$

As long as ore has Cu then need to add CN⁻ - How much

~~11.240~~ 1 lb - 2000 lbs .0005
million

* - ZINC Costs Fall out - Clarifiers fallout until RO.
UNKNOWN - If drop process solution to 50ppm
what happens to Au extraction

* - Will not have a .006 Recovery forever!
2140 tons solution / day $\times .003 = 6.07$
 $\times 30 = 189 \times 370 = 69,930 / 30 \text{ day}$
month.

9750 63750 FIRST YEAR

.006 opt @ 3 MONTHS

.003 opt @ 9 MONTHS

} \$ 1,048,950 - 63750
985,200

- 41,950 NSR + Ser

985,200

943,242

payroll 960,000 / year
(16,758)

Cu coming down = Cu going up

Can't find out whether or not
50 ppm CN⁻ will work until
clean up process solution

More Neut - Neut Pond needs cleaning

*** - C + Cu = Problem whether leaching
or neutralizing

With Carbon

→ Zinc costs fall out

DE " " " until R.O.

Replumb ^{Carbon} plant so ^{current} plant won't freeze in winter (not included w/ Deaeration Tower needs draining

Projected ounces

Manpower needs w/ just Carbon

Need 2 guys - 1 core of leach pad + 1 plant operator as long as circulating (safety) !!
Cannot see from plant to see if breakdowns and leaks occur

44°F 40° @ 38° TURN
NOV - DEC - JAN - FEB - MAR - ^{High}POTENTIAL FOR FREEZE if ON solution shut down.

→ Can't shut leaching down until
Total process solution ≤ 2 million gals and stay there !!

R.O. Efficiency goes down w/ cold temps - will freeze up if ~~not~~ goes down

850,000 TONS ORE

W/ 65,000 TON HEAPS When turn
on a heap - would get rid
of 1 - 1.5 million gallons
of solution

$$850,000 \div 65,000 = 13 \text{ heaps}$$

$$\text{low estimate on Pad} = 13 \text{ million} \\ + 3.7 \text{ in Surg} = 16.7 \text{ million}$$

$$\text{High estimate} = 19.62 + 3.7 \text{ in} \\ = 23.3 \text{ million gallons.}$$

MAR \rightarrow JUN + Add a minimum
of 5 million = 10" moisture
in 4 months

JUNE itself is a 6" month

	IN CIRCUIT	SPRING RUNOFF	TOTAL	1.3/Mont
MIN =	17,000,000	5,000,000	\$374K + labor etc. 22,000,000	17
MAX =	23,500,000	8,000,000	31,500,000 (535,500)	24

2.5k / 1.3 million
processed

NOTE JUST R.O.
DOES NOT INCLUDE R+C

Costs of RO Unit

Rent

	1994	95	96	97	98	99	00	
	4000	5000	6000	7000	8000	9000	10000	134
								70
								162
Rent	44,000	60,000	72,000	84,000	96,000	108,000	120,000	94
Transport	10,000	10,000	10,000	10,000	10,000	10,000	10,000	186
Membranes	80,000	-	80,000	-	80,000	-	80,000	118
								210
	<u>134</u>	<u>70</u>	<u>162</u>	<u>94</u>	<u>186</u>	<u>118</u>	<u>210</u>	<u>974</u>

Buying

	94	95	96	97	98	99	00	
								208
								134
Purchase	123	134	134	11	-	-	-	214
Transport	5	-	-	-	-	-	-	11
Membrane	80,000	-	80	-	80	5	80	80
								80
	<u>208</u>	<u>134</u>	<u>214</u>	<u>11</u>	<u>80</u>	<u>-</u>	<u>80</u>	<u>727</u>

974
 727
147
 Diff

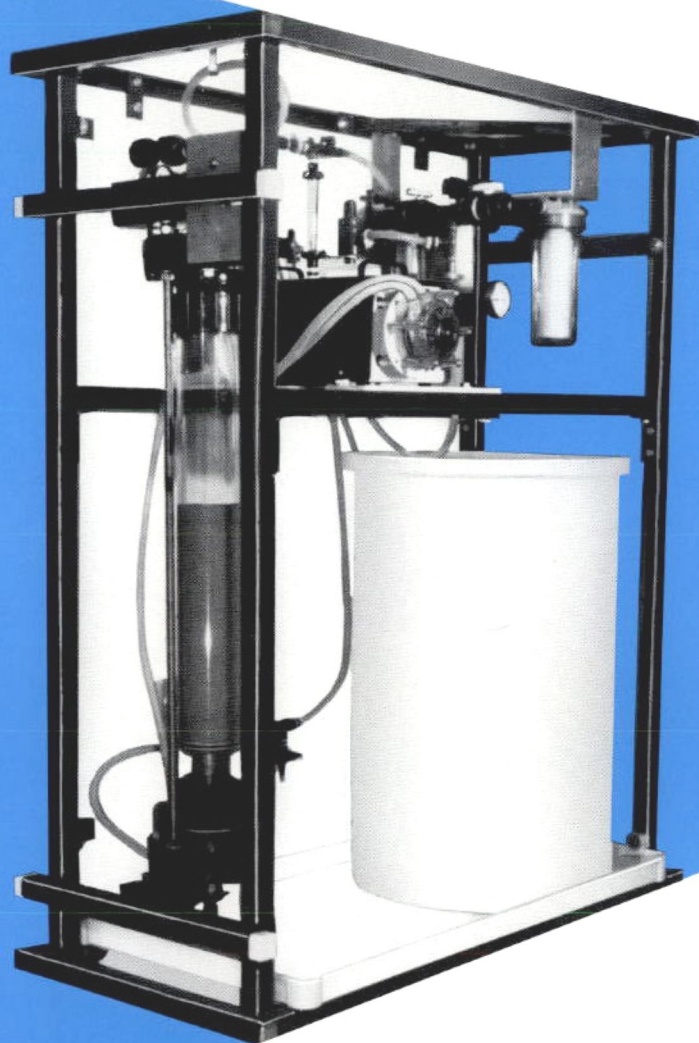
3 Yrs

Rent	Buy
134	208
70	134
<u>162</u>	<u>214</u>
366	556
	366

Loss 190

Membranes are very sensitive. If left in unit and kept moist they will work D.V.

***HEAVY METAL REMOVAL
FROM
INDUSTRIAL AND MUNICIPAL
EFFLUENTS***



Metre-General, Inc.

METRE-GENERAL.....THE TECHNOLOGY

The corporation, MGI, offers materials and processes that remove heavy metals from aqueous solutions with a selectivity as high as 3,000,000:1 over competing ions.

The technology uses compounds that have ultra-high selectivities for a specific ion or, more often, for a "family" of ions. Usually, but not always, the compounds are of the family of macrocycles known as crown ethers.

Crown ethers are ring-shaped molecules having a hole in the center correctly sized so that a heavy metal ion will diffuse into the hole and be retained selectively in competition with other ions or elements. The retention is in atomic and molecular ratios although the association is not a conventional chemical reaction.

The selectivity, in some instances, is as much as several million to one or greater. At equilibrium, for example, some heavy metals....such as lead....initially present in an aqueous solution in amounts of 100 parts per million (100,000 parts per billion) will, after brief contact with a specific crown ether, be reduced to 0.1 parts per billion. Ions of sodium potassium, calcium and magnesium, to illustrate the point, are not removed by any

measurable amount by the same crown ether as applied to the removal of lead.

These unusual compounds were considered to be so important to science and industry of the future that the 1987 Nobel Prize in chemistry was awarded to three researchers in this field of crown ethers.

MGI's capability and access to the technology is the result of having supported research for many years at several universities, as well as industrial laboratories, to develop materials to remove dissolved heavy metals selectively from aqueous waste streams.

The research and development activities are ongoing programs to assure continued leadership and advancement of the technologies with MGI being the exclusive licensee for the use of these materials for treating water, sewage and industrial wastewaters.

Patents, for the processes and analytical methods, have been granted and numerous other patent applications are in progress and pending here and in each of the major industrialized countries.

The Technology Provides For:

(a) Selecting and choosing specific macrocycles for certain ions over other ions;

(b) "Immobilizing" molecules by bonding them chemically to silica gel;

(c) Reducing the aqueous solubility of molecules to undetectable concentrations.

ANALYTICAL METHODS.....PROVEN TECHNIQUES

MGI's analytical method uses immobilized crown ethers to preconcentrate heavy metals before the sample is analyzed by an atomic absorption spectrophotometer.

Analytical precision can be enhanced by concentrating solutions by 1,000 to 10,000 times.

The analytical method provides an accuracy of ± 0.001 ppm at concentrations of 0.010 ppm. The analyses

Although research and development work on molecular recognition or host-guest-chemistry has been under way for over a quarter of a century, only recently have methods of immobilization been developed and perfected for varied applications.

Immobilized macrocycles are now available with high selectivity for every elemental cation..... and for some anions.

MGI has molecules, or ligands, which perform as do ion-exchange resins but that are extremely selective (conventional ion-exchange resins are not). Also available are other ion transfer agents that are highly soluble in commonly-used solvents and insoluble in aqueous solutions.

These ligands are a new class of chemically modified solids with unique variations that are highly selective for a wide range of heavy metals. The material is somewhat similar in appearance to ion exchange resin but is several orders of magnitude more selective.

Other Benefits Include:

- High loading capacities.
- Not affected by pH variation (-1 to 11).
- Not affected by temperature (up to several hundred degrees fahrenheit).
- Does not swell or shrink.
- Effective in the presence of most salts.
- Can be stored wet or dry.
- Can be regenerated through hundreds of cycles.

SYSTEM BENEFITS..... FOR INDUSTRY AND MUNICIPALITIES

■ Heavy metals concentration can be easily reduced, for example, to 0.05 to 1.0 parts per billion (i.e. 0.00005 mg/L to 0.001 mg/L).

■ No subsequent disposal problem is created by the use of this technology.

■ Simple process justifies the removal of heavy metal pollutants from effluents.

■ No capital equipment investment option; system can be provided on a service contract basis (MGI designs, constructs, operates and maintains).

Metre-General, Inc.

**9085 Marshall Court Westminister, CO 80030
303/430-0095 FAX: 303/430-7337**

OCTOLIG™ METAL REMOVAL SYSTEM

Metre-General, Inc. provides Octolig™ Metal Removing Systems that are operating successfully in industry. This brochure tells about our Octolig™ materials (silica-gel-immobilized ligands), and describes the MGI treatment systems in which the Octoligs™ are used.

Metre-General, Inc. has immobilized-ligands that remove ions selectively from water and sewage and waste streams. Two types of ligands are used. These ligands are crown ethers, and branched and linear amines.

The crown ethers are ring-shaped molecules that have a hole in the center. If the hole is of the correct size, neither too small nor too large, a heavy-metal ion will diffuse into that hole and be retained selectively in competition with the ions of other elements.

Branched amine molecules have nitrogen atoms that form a complex with certain heavy-metal ions.

In some instances the selectivity is as much as several million to one. For example, at equilibrium, after but a few minutes of contact, or, in some instances, after even a few seconds of contact, some heavy-metal elements in a water stream are reduced to 0.1 PPB (parts per billions, 0.0001 PPM).

REMOVAL OF CATIONS

(NICKEL, COPPER, ZINC, CADMIUM, SILVER, MERCURY)

Removal of cations (the cations of copper, nickel, zinc, cadmium, lead, mercury, and silver usually) is most often desired. The Octoligs™ and SuperLigs™ used by Metre-General do

that well. Removal of cations alone, or as a combination of cations, to produce concentrations of one PPM is accomplished easily. In actual practice the concentrations are reduced almost always to below 0.2 PPM, and generally to 0.01 PPM to 0.04 PPM. With small care final concentrations of 0.0002 PPM can be reached. Although at present we have not found a market for even lower concentrations, moderate-volume "pilot-plant" tests have produced concentrations of a fraction of a part per billion. If someone desired it, probably silver could be removed to concentrations of a few parts per trillion. The cations of sodium, potassium, calcium and magnesium generally are not complexed and retained; because sodium, potassium, calcium and magnesium in waste streams and water are not harmful, not removing them is good, because all the metal-removing capacity of the Octoligs™ is retained for the poisonous "heavy metals".

In those applications where the heavy-metal concentrations fluctuate extremely (in some instances through a range of 10 PPM to 2,000 PPM) the waste stream is given a mere simple pH-adjustment-and-precipitation-treatment with NaOH, followed by filtration, and then passage through the Octolig™ treatment system. The filter cake can have heavy metal concentrations of from 20% to 40%, without undue regard to the concentration of unprecipitated heavy metals remaining in the solution, because the subsequent Octolig™ treatment always reduces the final heavy metal concentration to under 0.2 PPM, and usually to 0.02 PPM.

It should be noted that below concentrations of 5 PPB, the analyses are performed with precision only with considerable difficulty.

REGENERATION OF THE OCTOLIGS™

When the immobilized-ligand is loaded with heavy metals to its capacity, the ligand is "regenerated" for reuse, and can be regenerated several hundred to several thousand times.

Regeneration of the immobilized ligand is done by washing the immobilized ligand with a water solution of a more powerful ligand, or by washing the immobilized ligand with a dilute acid solution. The resulting regenerant solution contains the heavy metals at concentrations thousands or hundreds of thousands of times greater than the concentration in the untreated waste stream. Usually the regeneration chemicals are required in little more than stoichiometric amounts.

The heavy metals are precipitated from that regenerant stream as hydroxides or oxides. This can be done along with the mere simple crude pH-adjustment-precipitation stage, when that precipitation operation is employed in combination with the Octolig™ treatment. The precipitate is filtered, produced as a very-concentrated cake, and shipped to a smelter to be reclaimed. Usually the concentration of the heavy metals in the dry filter cake is 20% to 40%.

For some elements, for example, nickel and copper, the regenerant stream can be treated by electrowinning to produce a metal scrap. With either procedure the "lean" regenerant solution is returned to the waste stream that

is entering the immobilized-ligand bed, and the remaining small concentration of heavy metals is removed.

MGI OCTOLIG™ TREATMENT COST

We do apply the immobilized ligands in complete systems for treating waste streams. Usually we install the treatment plant at our expense and charge a moderate sum for the service of removing the unwanted trace metals.

The rental charge varies according to the metal pollutant to be removed, and volume of waste stream to be treated. For volumes less than 20,000 gallons-per-month the rental charge might be \$1,000 per month. For a single metal, and 100,000 gallons per month, the rental charge might be \$3,000 per month. We estimate that removal of small parts-per-billion of a heavy metal, lead for example, from 100,000,000 gallons of water per day would cost about \$0.10 to \$0.20 per thousand gallons.

PERFORMANCE OF MGI OCTOLIG™ TREATMENT SYSTEM

With this brochure is more information on our materials, information on actual treatment installations.

INFORMATION WE NEED FROM YOU

We want to offer the services of our Octolig™ systems on your specific application or applications. If you have a specific application, please tell us (a) the rate of flow of the solution, (b) the total volume of the solution, (c) the pH of the solution, (d) the concentration of each of the ions dissolved in the solution, (e) the rate of increase in the concentration of the pollutant(s) if the solution is static and if pollutant concentrations increase with time, and (f) the allowable concentration of each pollutant after treatment.

Metre-General, Inc.

9085 Marshall Court

Westminster, CO 80030

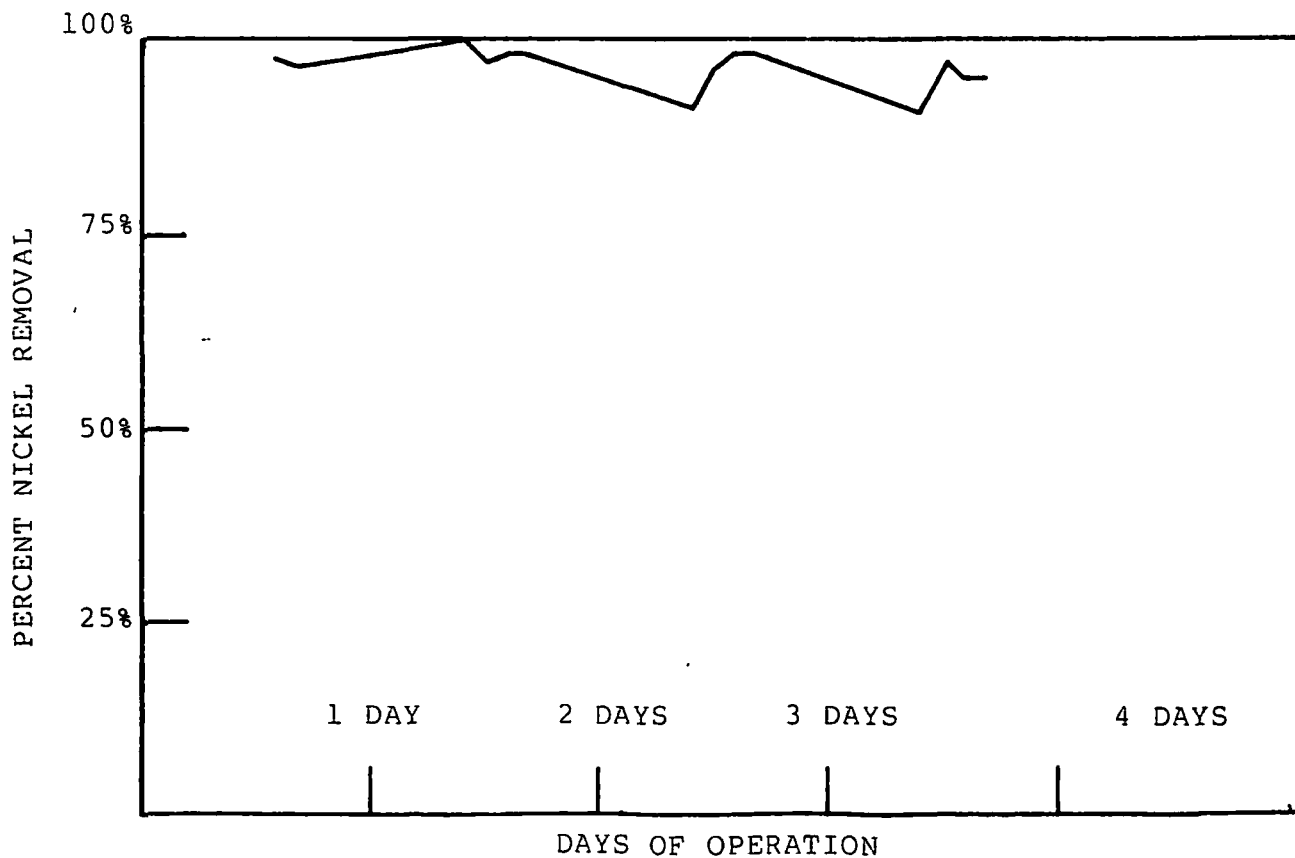
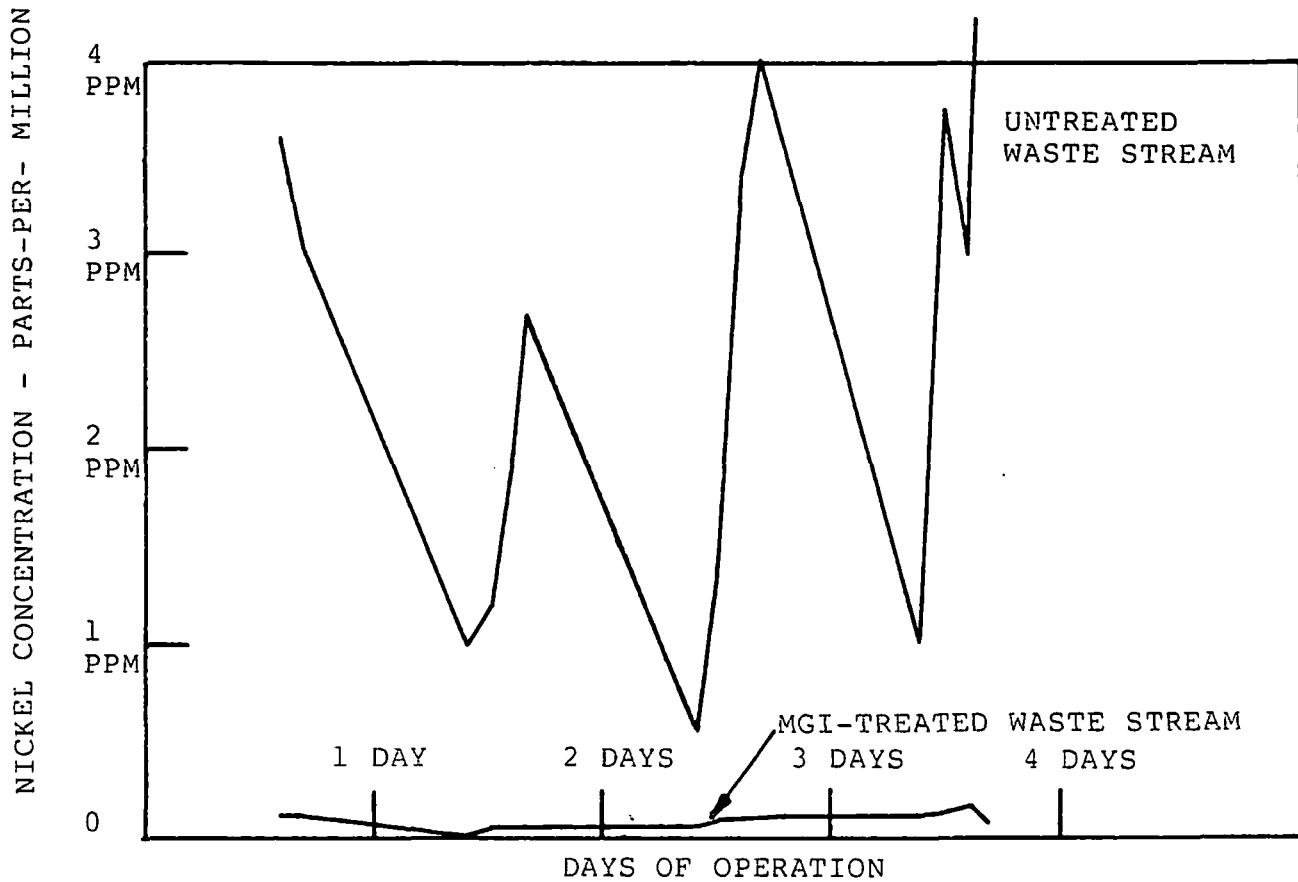
303/430-0095 FAX: 303/430-7337

OCTOLIG™ PERFORMANCE

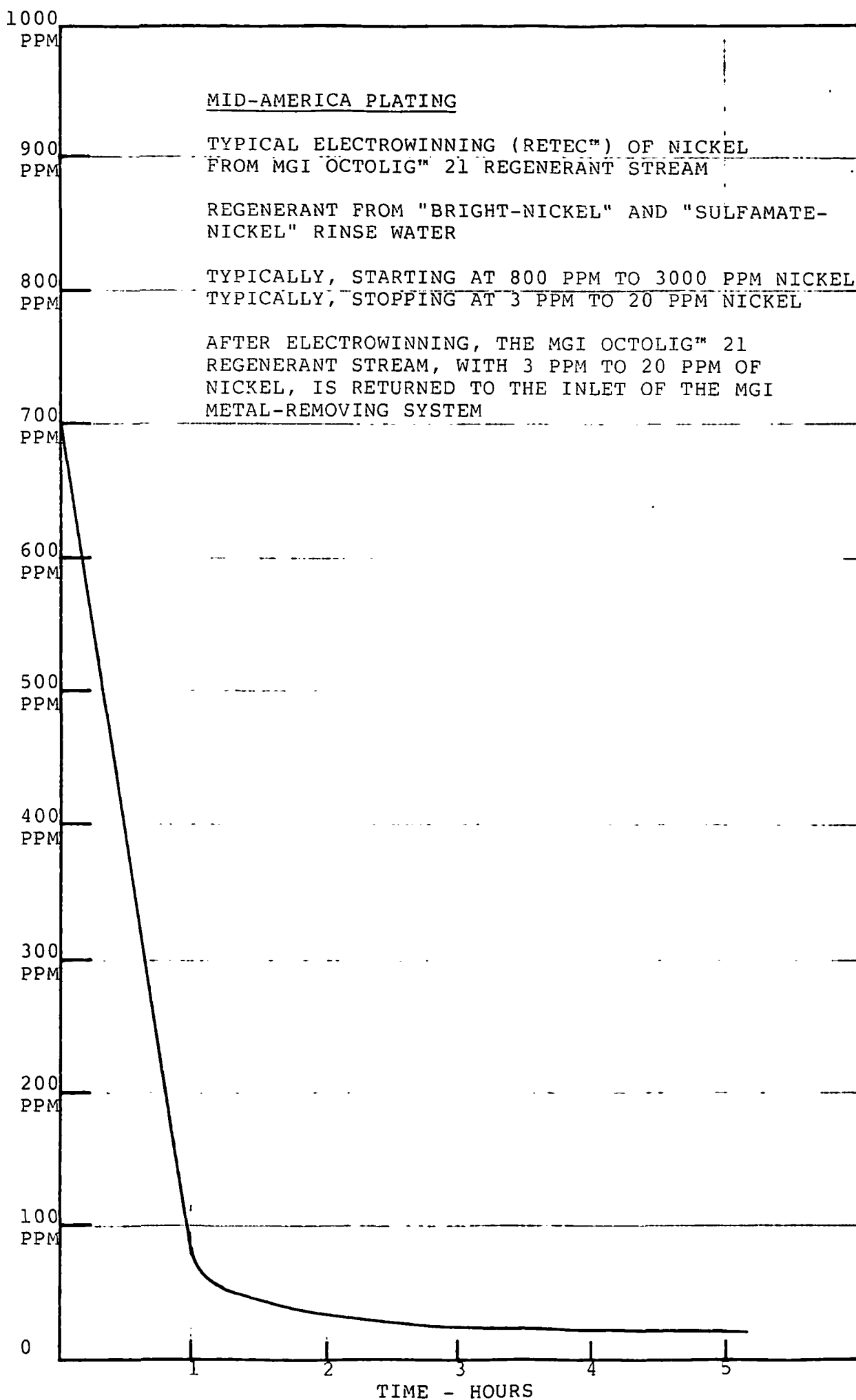
HEAVY-METAL REMOVAL

MID-AMERICA PLATING

TYPICAL ONE-WEEK LOADING-REGENERATION CYCLE
"BRIGHT NICKEL" ELECTROLESS NICKEL, SULFAMATE-NICKEL RINSE WATER
MGI-TREATED RINSE WATER RETURNED CONTINUALLY TO RINSE TANK AND REUSED
WATER SAVING 80% TO 90%, USUALLY 90%



NICKEL - PARTS-PER-MILLION



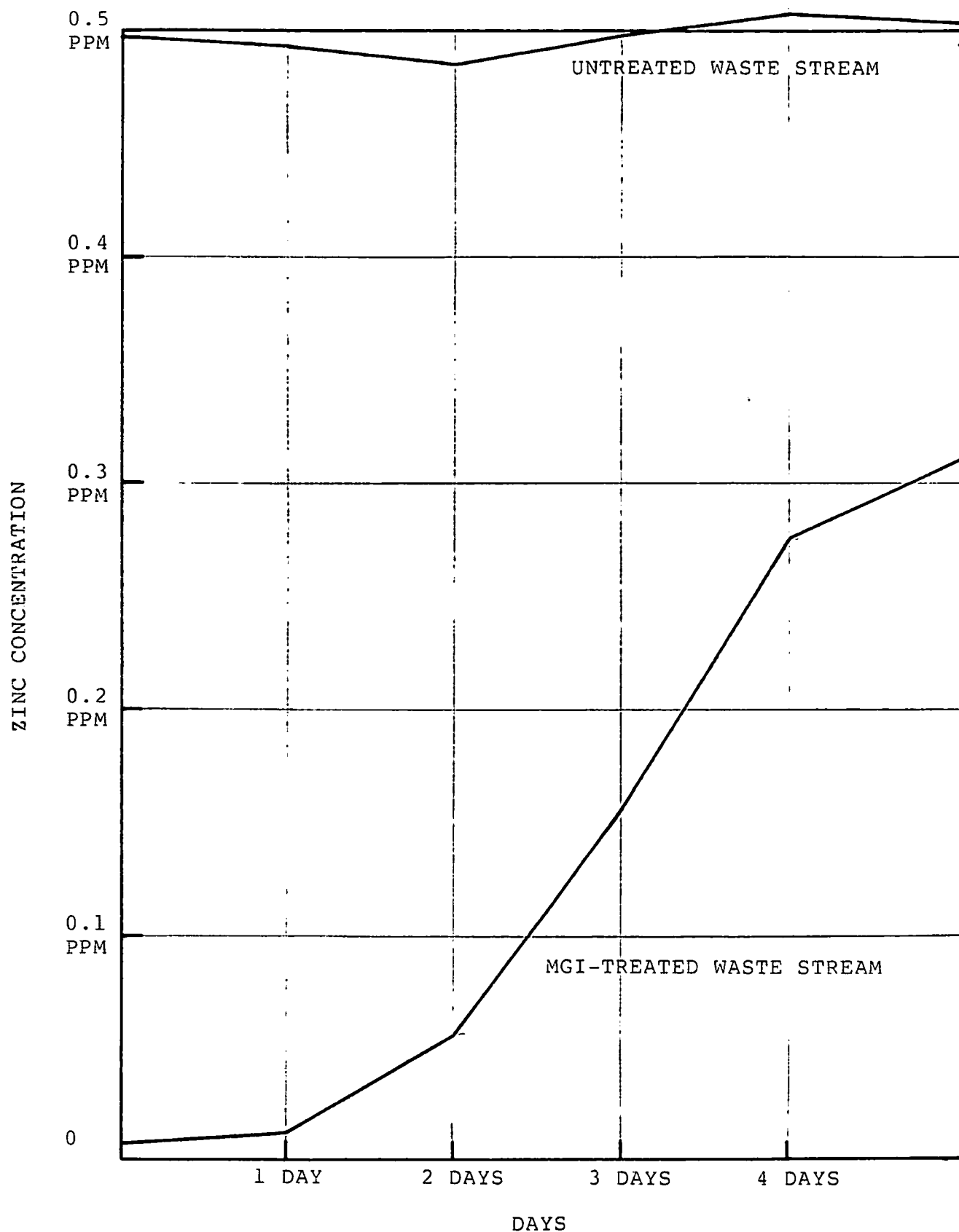
COLORADO DIVISION OF WILDLIFE

MULTI-AQUARIUM WASTE STREAM

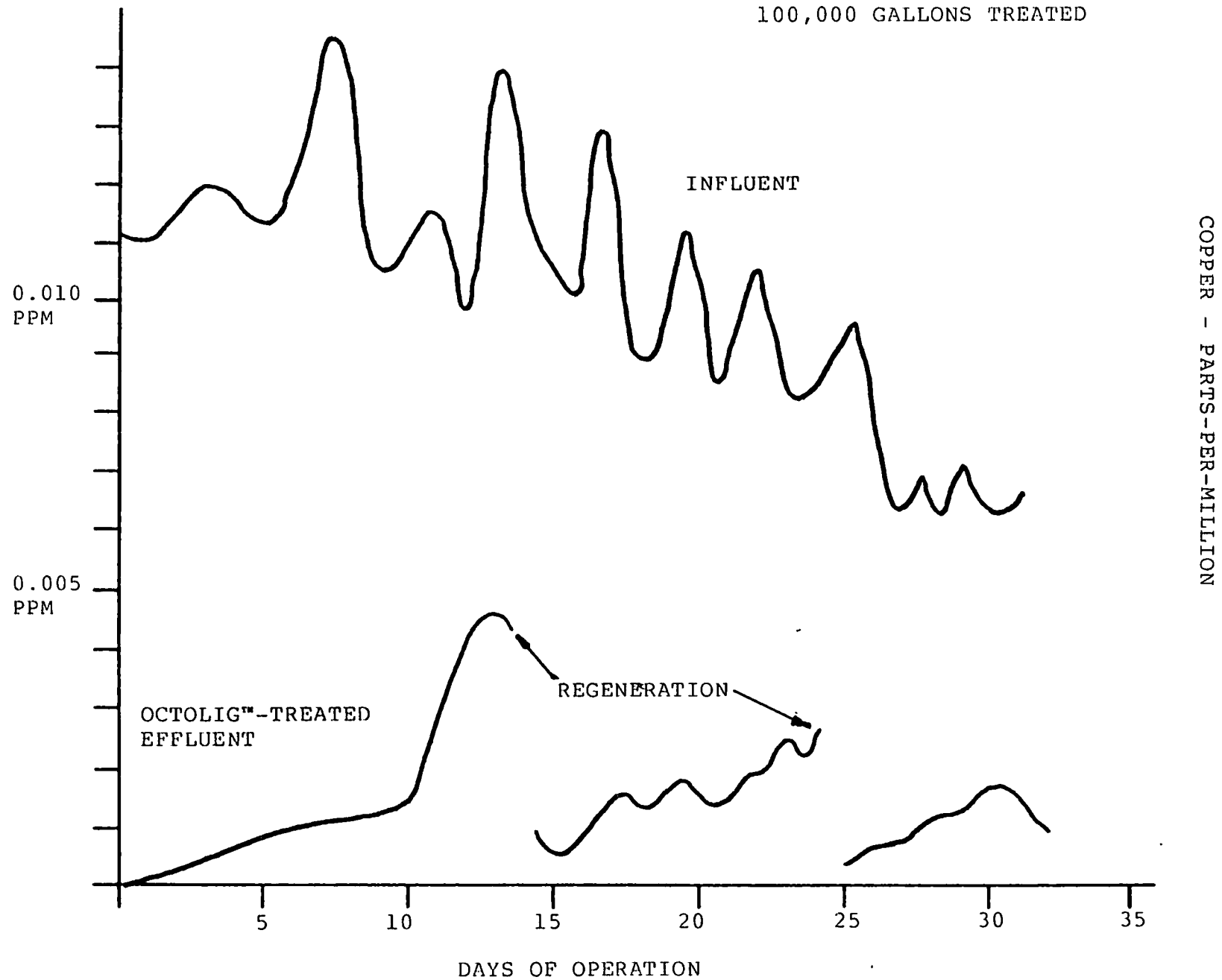
TESTS IN ADVANCE OF 32,000 GALLONS PER DAY MGI SYSTEM

CONCENTRATIONS IN UNTREATED WASTE STREAM

ZINC 0.5 PPM, CADMIUM 0.005 PPM IRON - > 4 PPM (ESTIMATED)



"LEADVILLE DRAIN" TREATMENT
100,000 GALLONS TREATED





MODEL 15CM
OCTOLIG™
METAL REMOVING SYSTEM

METRE-GENERAL, INC.
9085 MARSHALL COURT
WESTMINSTER, COLORADO 80030
TELEPHONE: (303) 430-0095 FAX: (303) 430-7337

Metre-General, Inc. Octolig™ Metal Removing System

Standard Commercial System For Treating Aqueous Waste Streams

Volumes Up To: (12,000 gallons per day) (45,000 liters per day)

With Heavy-Metal Concentrations Up To
60 PPM The MGI Octolig™ MRS Produces A Treated Stream
With A Heavy-Metal Concentration Of 0.00005 PPM To 0.10 PPM

The Model 15CM MGI Octolig™ MRS as shown, that can treat up to (700 gallons) (2,600 liters) of wastewater per day, contains the entire treatment system, including pumps, controls, Octolig™ bed, filters, piping and valves. Balance tanks, regenerant-chemical solution tanks, and mixer are used in addition to the complete MGI Octolig™ MRS.



MODEL 60CM
OCTOLIG™
METAL REMOVING SYSTEM

METRE-GENERAL, INC.
9085 MARSHALL COURT
WESTMINSTER, COLORADO 80030
TELEPHONE: (303) 430-0095 FAX: (303) 430-7337

Metre-General, Inc. Octolig™ Metal Removing System

Standard Commercial Systems For Treating Aqueous Waste Streams

Volumes Up To: (12,000 gallons per day) (45,000 liters per day)

With Heavy-Metal Concentrations Up To
60 PPM The MGI Octolig™ MRS Produces A Treated Stream
With A Heavy-Metal Concentration Of 0.00005 PPM To 0.10 PPM

The Model 60CM MGI Octolig™ MRS as shown, that can treat up to (12,000 gallons) (45,000 liters) of wastewater per day, contains the entire treatment system, including pumps, controls, Octolig™ bed, filters, piping and valves. Balance tanks, regenerant-chemical solution tanks, and mixer are used in addition to the complete MGI Octolig™ MRS.



960 Ames Avenue
Milpitas, CA 95035
408-946-1520
FAX 408-945-1549

Via Courier and Fax: 605/578-1709

Mr. Martin Quick
V.P. Operations
BROHM MINING CORP.
P.O. Box 485
Deadwood, South Dakota 57732

RE: Proposed Change to Brohm Purchase Order #10619

Dear Mr. Quick:

The purpose of this letter is to notify you that we received your March 3, 1994 fax regarding the proposed changes to the above referenced purchase order.

Please be advised that we will not accept these revisions to the purchase order. The terms, pricing, and conditions outlined in our January 24, 1994 proposal and your purchase order #10619 are valid.

Sincerely,

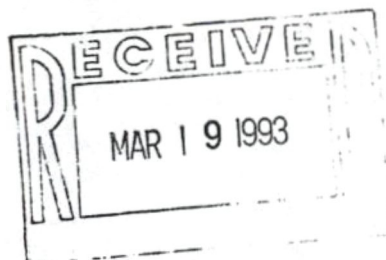
ARROWHEAD INDUSTRIAL WATER, Inc.

Scott Whittaker
Sales Engineer

cc: Mr. Nate Silvestri
Mr. Jim Griebel
Mr. Scott Kuechle

MAR 19 '93 17:43 BROHM MINING CO

P.1



226

FOLLOW UP
BY
FILE
K

FACSIMILE TRANSMISSION COVER SHEET

DATE: 3-19-93
NAME: Ray Grant
FIRM: Castle Rock
FAX NO: 1-303-298-1525
FROM: K. Wall

NO. OF PAGES (including cover sheet) 5

COMMENTS: _____

IF YOU DO NOT RECEIVE ALL PAGES, PLEASE CALL: (605) 578-2107
AS SOON AS POSSIBLE.

FACSIMILE OPERATOR: K. Wall

FACSIMILE NUMBER: (605) 578-1709

South Dakota Office: P.O. Box 485, Deadwood, South Dakota 57732
Telephone: (605) 578-2107
Telecopier: (605) 578-1709

Brohm Mining Corp. is a wholly owned affiliate of Magma Gold Corporation

EIC, Corporation
1355 South Colorado Boulevard
Suite 316
Denver, Colorado 80222
Tel 303/692-0272
Fax 303/692-8870

April 12, 1991
EIC Project No. 02502

Mr. Vic Miller
Brohm Mining Corporation
P.O. Box 485
Deadwood, South Dakota 57732

Dear Vic,

Please find attached a revised Table 1 for our report, "Oxide Heap Leach Water Balance, Brohm Mining Corporation". The "Cumulative Excess Gain" row on page 3 was corrected as discussed. Note that this change does not affect the conclusions of the report. My apologies for this oversight, please let me know if there are any further questions.

Sincerely,

EIC, CORPORATION

Dirk van Zyl
Dirk Van Zyl, P.E., Ph.D.
President



DVZ/gg

113.1tr

Component	January	February	March	April	May	June	July	August	September	October	November	December
4.0 Solution Gain/Loss												
Inflow Minus Consumption	(182,588)	(182,247)	1,352,240	34,289	(191,271)	246,724	(347,748)	(345,510)	(183,944)	(155,112)	(159,107)	(182,179)
5.0 Excess Volume to be Stored												
Cumulative Excess Gain	0	0	1,352,240	1,386,528	1,195,258	1,441,982	1,094,233	748,724	564,780	409,667	250,560	68,381
6.0 Storage Requirements on Pad												
Total Pond Vol Available	752,848	752,848	752,848	752,848	752,848	752,848	752,848	752,848	752,848	752,848	752,848	752,848
Pad Volume Required	0	0	599,392	633,681	442,410	609,134	341,386	0	0	0	0	0
Approximate Elev on Pad (no freeboard)			5557	5558	5556	5558	5554					

$\downarrow \times 7.48 =$
 5,154,700 gal

Table 1
Brohm Mining Corporation
Gilt Edge, Deadwood, South Dakota

Heap Leach Water Balance

INPUT PARAMETERS

(a) Catchment Areas

Total Leach Pad Area (ft ²)	640,530
Pad Area under Leach and Rinse, sf	300,000
Surge Pond (ft ²)	58,900
D.E. Pond (ft ²)	4,200
Neutralization Pond (ft ²)	12,100
Trough (ft ²)	6,640

(d) Pond Volumes (gallons)

Surge Pond	7,131,300
Neutralization Pond	637,000

(f) Storage Available on Pad (all values in ft³)

Elevation(ft)	Empty Pad Volume	Cumulative	Ore on Pad Volume	Cumulative	Open Space Volume	Pore Space Volume	Total Volume
5546	17,902	17,902	5,978	5,978	11,926	299	12,223
5548	68,270	86,172	35,770	41,748	44,424	2,087	46,511
5550	158,476	244,648	102,180	143,928	100,720	7,196	107,916
5552	287,485	532,133	203,824	347,752	184,381	17,388	201,769
5554	456,796	988,929	340,911	688,663	300,266	34,433	334,699
5556	653,960	1,642,889	505,050	1,193,713	449,176	59,686	508,862
5557	403,114	2,046,003	317,819	1,511,532	534,471	75,577	610,048
5558	449,607	2,495,610	358,439	1,869,971	625,639	93,499	719,138
5559	491,440	2,987,050	394,657	2,264,628	722,422	113,231	835,653
5560	527,750	3,514,800	475,650	2,740,278	774,522	137,014	911,536
5561	534,000	4,048,800	500,250	3,240,528	808,272	162,026	970,298
5562	561,200	4,610,000	469,900	3,710,428	899,572	185,521	1,085,093
5564	1,226,000	5,836,000	972,500	4,682,928	1,153,072	234,146	1,387,218

(c) Moisture Content (%)

Ore from Pit	5
Under Leach	15
Residual	10

(e) Extra Evaporation Areas

From Pad after PMP, sf	62,500
------------------------	--------

5,379,000 gal.
6,251,000 gal

WATER BALANCE CALCULATIONS

Component	January	February	March	April	May	June	July	August	September	October	November	December	
1.0 Climatic Information													
(a) Average Conditions													
Precipitation (in)	1.38	1.43	2.41	3.77	3.82	4.08	2.37	2.35	1.41	1.76	1.38	1.44	27.60
Lake Evaporation(in)	0.00	0.00	2.50	3.20	5.00	4.20	6.50	6.20	4.90	4.40	3.20	0.00	40.10
Pan Evaporation (in)	0.00	0.00	1.26	1.62	2.53	2.13	3.29	3.14	2.48	2.23	1.62	0.00	20.30
Wobler Evap, % of Inflow	0.00	0.00	0.00	1.50	3.50	3.00	4.00	4.00	3.50	3.00	1.50	0.00	
(b) Extreme Events													
PHP (in)	0.00	0.00	19.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
1:100 yr 24 hour(in)	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	
2.0 Inflow													
(a) Pad and Ponds Average Precipitation Conditions													
Pad (ft^3)	0	0	355,494	201,233	203,902	217,780	126,505	125,437	75,262	93,944	73,661	0	
Surge Pond (ft^3)	6,773	7,019	11,829	18,504	18,750	20,026	11,633	11,535	6,921	8,639	6,773	7,068	
D.E. Pond (ft^3)	483	501	844	1,320	1,337	1,428	830	823	494	616	483	504	
Neutral. pond (ft^3)	1,392	1,442	2,430	3,801	3,852	4,114	2,390	2,370	1,422	1,775	1,392	1,452	
Trough (ft^3)	764	791	1,334	2,086	2,114	2,258	1,311	1,300	780	974	764	797	
TOTAL	9,412	9,753	371,931	226,945	229,954	245,606	142,668	141,464	84,878	105,948	83,073	9,821	
(b) Pad and Ponds Extreme Precipitation Conditions													
PHP (ft^3)	0	0	1,179,871	0	0	0	0	0	0	0	0	0	
1:100 yr24hour(ft^3)	0	0	0	0	0	361,185	0	0	0	0	0	0	
3.0 Consumption													
Ore Wetting,cf	192,000	192,000	192,000	Flooded	Flooded	Flooded	Flooded	Flooded	192,000	192,000	192,000	192,000	
Evap from Ponds,cf	0	0	7,563	20,053	31,333	26,320	40,733	38,853	14,823	13,310	9,680	0	
Evap from Pad (normal),cf	0	0	0	0	0	0	0	0	62,000	55,750	40,500	0	
Evap from wobblers on pad	0	0	0	155,936	363,850	311,872	415,829	415,829	0	0	0	0	
Evap from Pad after PHP	0	0	0	16,667	26,042	21,875	33,854	32,292	0	0	0	0	
TOTAL	192,000	192,000	199,563	192,656	421,225	360,067	490,416	486,974	268,823	261,060	242,180	192,000	

WATER BALANCE CALCULATIONS

Component	January	February	March	April	May	June	July	August	September	October	November	December	
1.0 Climatic Information													
(a) Average Conditions													
Precipitation (in)	1.38	1.43	2.41	3.77	3.82	4.08	2.37	2.35	1.41	1.76	1.38	1.44	27.60
Lake Evaporation(in)	0.00	0.00	2.50	3.20	5.00	4.20	6.50	6.20	4.90	4.40	3.20	0.00	40.10
Pan Evaporation (in)	0.00	0.00	1.26	1.62	2.53	2.13	3.29	3.14	2.48	2.23	1.62	0.00	20.30
Wobler Evap. % of Inflow	0.00	0.00	0.00	1.50	3.50	3.00	4.00	4.00	3.50	3.00	1.50	0.00	
(b) Extreme Events													
PMP (in)	0.00	0.00	19.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
1:100 yr 24 hour(in)	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00	
2.0 Inflow													
(a) Pad and Ponds Average Precipitation Conditions													
Pad (ft^3)	0	0	355,494	201,233	203,902	217,780	126,505	125,437	75,262	93,944	73,661	0	
Surge Pond (ft^3)	6,773	7,019	11,829	18,504	18,750	20,026	11,633	11,535	6,921	8,639	6,773	7,068	
D.E. Pond (ft^3)	483	501	844	1,320	1,337	1,428	830	823	494	616	483	504	
Neutral. pond (ft^3)	1,392	1,442	2,430	3,801	3,852	4,114	2,390	2,370	1,422	1,775	1,392	1,452	
Trough (ft^3)	764	791	1,334	2,086	2,114	2,258	1,311	1,300	780	974	764	797	
TOTAL	9,412	9,753	371,931	226,945	229,954	245,606	142,668	141,464	84,878	105,948	83,073	9,821	
(b) Pad and Ponds Extreme Precipitation Conditions													
PMP (ft^3)	0	0	1,179,871	0	0	0	0	0	0	0	0	0	
1:100 yr 24hour(ft^3)	0	0	0	0	0	361,185	0	0	0	0	0	0	
3.0 Consumption													
One Wetting,cf	192,000	192,000	192,000	Flooded	Flooded	Flooded	Flooded	Flooded	192,000	192,000	192,000	192,000	
Evap from Ponds,cf	0	0	7,563	20,053	31,333	26,320	40,733	38,853	14,823	13,310	9,680	0	
Evap from Pad (normal),cf	0	0	0	0	0	0	0	0	62,000	55,750	40,500	0	
Evap from wobblers on pad	0	0	0	155,956	363,850	311,872	415,829	415,829	0	0	0	0	
Evap from Pad after PMP	0	0	0	16,667	26,042	21,875	33,854	32,292	0	0	0	0	
TOTAL	192,000	192,000	199,563	192,656	421,225	360,067	490,416	486,974	268,823	261,060	242,180	192,000	

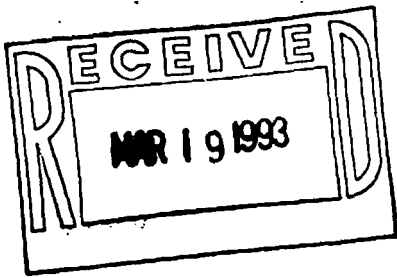
cf * 7.48 = gals.
Wobblers (x 10³)

1,164 2,722 2,333 3,110 3,110

Apr 2,488

1,441 3,151 2,693 3,668 3,643
Apr 2,989 x 10³ gal.

TOTAL Evap. x 10³



H.C. Osborne and Associates
12885 Lanewood Drive
Commerce City, Colorado 80022

298-1525

FACSIMILE TRANSMITTALCurrent Date: 3/19/93To: Ray GrantFax Number: 298-1525Company: CastleFrom: H. OsborneFax Number: 654-0431

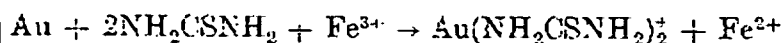
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TOTAL NUMBER OF PAGES (INCLUDING THIS PAGE) 6Comments:

Now you know all there is to know about zinc prep - except how to make it work? which is exactly where we're at. I've been trying to get JT and others to try a bucket of aluminum dust with no success.

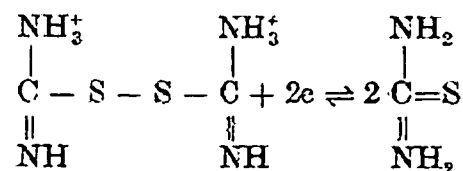
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ther than oxygen. Interest^{56,57} first arose in the Soviet Union but has now spread to South Africa where the process is at present being studied intensively. The Russian work arose from the search for a reagent less toxic than cyanide and less prone to interference from copper and antimony minerals. The South African investigations have diverse aims. The first of these is to find an acid leaching process for gold that would allow the simultaneous leaching of gold and uranium from the Witwatersrand ores. The second stems from the suggestion that considerable economies would be effected if ores from deep mines were processed underground. This expedient would require a more rapid, less hazardous process than cyanidation, both of which requirements the thiourea process promises to satisfy. At the present time the major drawback of the method appears to be the high cost of reagents, stemming principally from the instability of thiourea under the conditions of leaching. The principle leaching reaction when ferric ion is used as the oxidant is



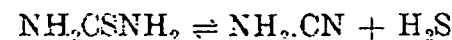
The reaction is rapid and extractions of about 95 to 99% can be achieved in two hours. The speed of this reaction relative to cyanidation may be accounted for by the same factors that apply in chlorination of gold. The gold surface apparently does not passivate in acid solution. The rate is controlled by diffusion of reagents to the surface and therefore, can be much higher when the reagent is soluble, as is ferric sulphate, than when it is sparingly soluble, as is oxygen. This resistance to the formation of surface films under acid conditions probably accounts for the fact that copper and antimony sulphide minerals do not interfere with the dissolution of gold in thiourea.

Thiourea can be oxidized to formamidine disulphide. The reaction



has a standard potential of 0.42 volts.⁵⁸ Therefore, thiourea is readily oxidized by ferric ion. The latter reaction is probably one of the principal sources of loss of reagent in

the gold leaching process, and it is one that will become more serious as the concentration of ferric ion increases. On the other hand, it has been suggested that formamidine disulphide can act as the oxidant for the dissolution of gold by thiourea⁵⁹. Another mode of decomposition, which is thought to be of importance, is the formation of cyanimide and hydrogen sulphide



The reagent is not stable in solutions less acid than pH 4, and decomposes with the liberation of sulphur.

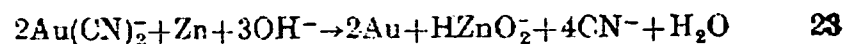
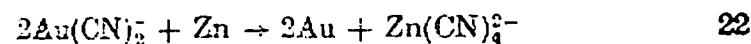
RECOVERY OF GOLD FROM SOLUTION

CEMENTATION BY ZINC

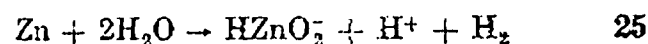
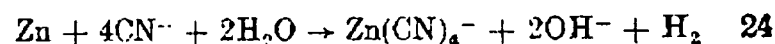
The zinc cementation process for the recovery of gold and silver from cyanide solutions was introduced in 1890. During the following thirty years three major modifications were introduced, which together made the process one of great efficiency and much improved economy and convenience. The first was the addition of lead salts for the formation of the lead-zinc couple (1894). The second, the replacement of zinc shavings by zinc dust, although first used in 1897, was not generally adopted until after 1916, when the third of the innovations was made—de-aeration of solutions before precipitation. The period of development and innovation was also one in which the mechanism of the process aroused much interest and discussion. Perhaps naturally, this interest declined once the process had been freed of its major metallurgical and economic shortcomings. As a result, there has been little increase in knowledge of the workings of the process since that time. In recent years interest in cementation, or 'contact precipitation' has been centred on the precipitation of copper from acid solutions by iron, and some relatively sophisticated studies have been made.⁶⁰ Whereas some systems other than copper-iron have also received some attention, it is remarkable that gold-zinc-cyanide is not among them.

The potential-pH diagrams in Figure 4 give an indication of the reactions that are possible in the system under different conditions. They show that the precipitation of

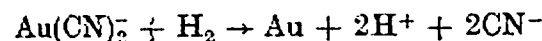
gold can take place by direct replacement reactions, such as



Zinc can also react in alkaline cyanide solutions to produce hydrogen:



Since the reduction of $\text{Au}(\text{CN})_2^-$ to gold by hydrogen is favoured thermodynamically under a wide range of conditions, including most of those encountered in practice, it is also possible that the precipitation of gold from cyanide solutions does not proceed directly, as in reactions 22 and 23, but through the intermediate formation of hydrogen:



On the other hand, for certain conditions under which zinc readily precipitates gold from solution (e.g., $[\text{Au}(\text{CN})_2^-] = 10^{-5} \text{ M}$, $[\text{CN}^-]_{\text{total}} = 10^{-3} \text{ M}$, $\text{pH} = 10$), hydrogen will not reduce $\text{Au}(\text{CN})_2^-$. Furthermore, it is known that gold is not in fact precipitated from cyanide solutions by hydrogen at atmospheric pressure. At higher pressures and temperatures, the reaction does take place but it is relatively slow. Times of the order of hours are required for completion of precipitation⁶¹, in comparison with the minutes or seconds⁶² required by cementation. It is clear that the direct displacement reaction is the major, if not only, mechanism by which zinc precipitates gold.

On the evidence presently available one cannot completely discount the possibility that there may be conditions under which some reaction takes place by the alternative path involving the intermediate formation of hydrogen. However, it is most likely that the formation of hydrogen in this system is entirely a side reaction whose only importance is as a consumer of zinc.

Like cyanidation, cementation is a heterogeneous redox process. Zinc is dissolved at the anodic areas of the surface, and the electrons released serve to reduce the aurous ions at the cathodic areas.

The addition of lead salts is thought to enhance the precipitation by contributing to the action of the local electrochemical cells, but the mechanism of its action is unclear. The lead is known to be reduced at the zinc surface and to be deposited on it forming cathodic areas. Therefore, gold precipitated subsequently will tend to deposit in these areas. It has been suggested that in this way the lead prevents the zinc surface from being totally occluded by the gold deposit, and thus maintains the essential contact between the solution and the anodic areas⁶³. If the addition of lead is increased beyond a certain point, the recovery of gold is severely reduced. The maximum addition to a pure gold cyanide solution has been determined by one worker to be $3 \times 10^{-4} \text{ M}$ (100 p.p.m.) when the zinc addition is 265 p.p.m.⁶³. In practice, additions of lead are about a tenth of this level.

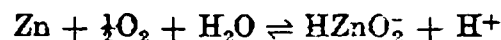
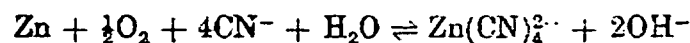
The rate of reaction obeys an equation of the form^{64, 65, 66},

$$\log \frac{C_0}{C_t} = kAt. \quad 26$$

where C_0 is the initial concentration of $\text{Au}(\text{CN})_2^-$ in solution, C_t is the concentration at a time t after the start of reaction, A is the surface area of zinc, and k is a constant. It is, therefore, first order with respect to the concentration of aurocyanide in solution, and directly dependent on the area of precipitant. Other evidence leaves little doubt that the reaction, in common with other cementation reactions⁶⁰, is diffusion-controlled under all the conditions of concentration and agitation that are likely to be encountered in practice. Thus the rate has a small positive temperature coefficient, and the overall activation energy is about 13 kjoule mol^{-1} . Since it is the diffusion of the aurocyanide that is rate-controlling, it is the reaction at the cathodic sites that governs the progress of the precipitation. The anodic reaction apparently has significant influence only under conditions where the anodic sites are blocked by the deposition of insoluble products and films. In the course of the precipitation of the gold content of a solution, the rate of reaction falls steadily. At the same time, the potential of the cathodic sites at the surface falls towards that of the anodic sites which remains almost constant⁶⁷.

The presence of oxygen in solution affects the process of gold cementation adversely in a number of ways. Firstly, the rate of reaction varies inversely with the partial pressure of

oxygen⁶⁵. Secondly, there is a tendency for the precipitated gold to redissolve under the influence of oxygen. However, if the gold remains in contact with zinc metal it will form the cathodic member of a local electrochemical cell, and the effect of oxygen will be to dissolve preferentially the more anodic zinc. Since the gold deposit is a compact and adherent one, redissolution is unlikely to be of importance in practice. Thirdly, alternative mechanisms are established for the dissolution of zinc:



Unlike reactions 24 and 25, these do not involve the liberation of hydrogen which is a slow stage. Thus the rate and extent of the dissolution of zinc are markedly increased by the presence of oxygen. Finally it has also been suggested that oxygen may act as a depolarizer for the cathodic areas of the zinc surface by reacting with the hydrogen that is formed there by reactions such as 24 and 25, and may, therefore, actually be beneficial to cementation. Evidence has been put forward⁶⁸ to show that the completeness of precipitation is increased by small concentrations (less than 1 p.p.m.) of oxygen in solution. However, so small were the effects observed that the conclusion must be accepted with considerable reservations. In this context it is perhaps of interest that solutions proceeding to precipitation after de-aeration by the Crowe vacuum process have oxygen concentrations in the range 0.6 to 1.3 p.p.m.⁶⁹.

It is generally accepted that cementation is sensitive both to the alkalinity and to the free cyanide concentration of the solution. However, suitable experimental data are not available to allow the effects of these reagents to be characterized in any detail. Leblanc⁶³ has shown that the recovery by precipitation falls off markedly for pH values below 8 at cyanide concentrations of 2 to 3 $\times 10^{-3}$ M. Above pH 8 the recovery increases gradually to a maximum at a pH of about 11.5. It has also been shown that the rate of precipitation increases slightly as the alkalinity increases from 10⁻³ M to 0.1 M⁶⁶. At very low cyanide concentrations and alkalinity, little or no precipitation takes place^{65, 70}. The reasons for these effects are by no means certain, nor is it certain how generally applicable the results described are.

Much better established is the finding that the pH and cyanide concentration of the solution, together with the

total concentration of zinc in oxidized forms, $[\text{Zn(II)}]_{\text{total}}$, combine in a complex manner to determine whether the Zn(II) remains in solution or precipitates. This topic has been introduced above in the discussion of Figure 4.

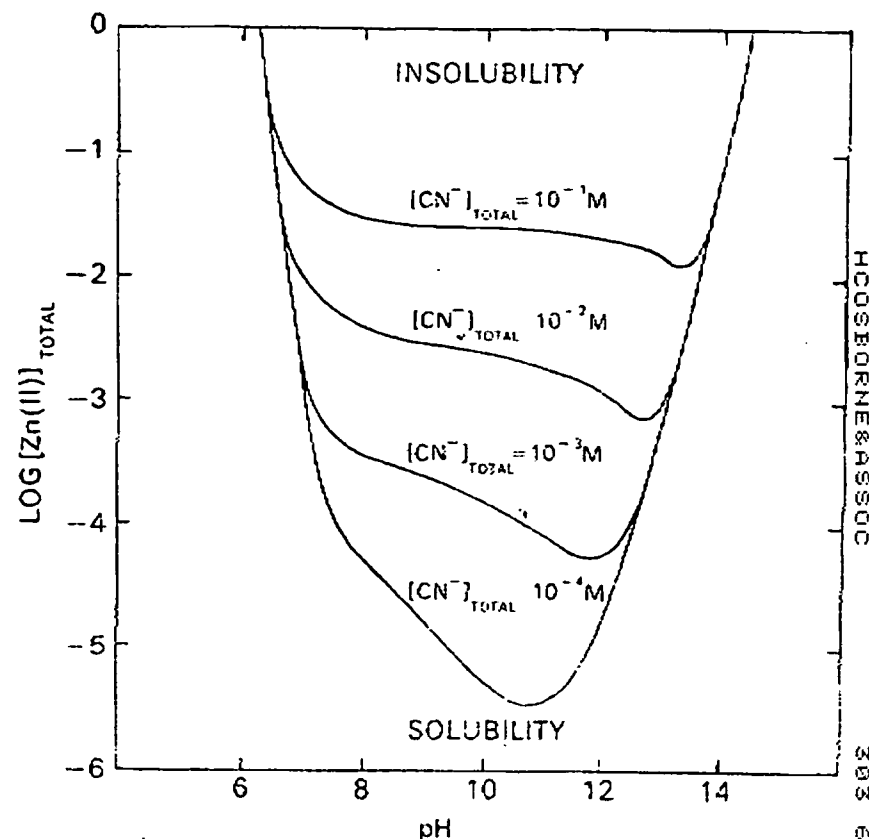


Fig. 9.—Domains of solubility and insolubility of Zn(II) in cyanide solutions at 25°C.

Figure 9 shows more clearly how the domains of solubility and insolubility of Zn(II) vary with pH, $[\text{Zn(II)}]_{\text{total}}$, and $[\text{CN}^-]_{\text{total}}$. Precipitation of Zn(OH)_2 is of importance in the cementation of gold, because it tends to take place at the surface of the zinc and has the effect of retarding the reaction, and even stopping it entirely^{63, 69, 70, 71}. The mechanism of this action involves, primarily, the formation of a barrier between the solution and the surface sites, thereby preventing access of reagents to or removal of products of reaction from the surface. As the precipitation proceeds, the whole of the zinc surface becomes covered by a macroscopic layer of zinc hydroxide. In essence, this is the

"white precipitate" that caused severe problems in the cementation of gold on zinc shavings.

The data set out in Figures 4 and 9 make it clear that difficulties due to the precipitation of zinc hydroxide can be avoided, if the alkalinity and cyanide concentration of the solution are controlled, and above all, if the concentration of zinc in the oxidized state is kept to a minimum. Vacuum de-aeration, which was introduced primarily as a means of reducing the high zinc consumption that resulted from the use of zinc dust, had the important secondary benefit of reducing the danger of interference from the precipitation of zinc hydroxide.

Although the liberation of hydrogen by zinc from alkaline cyanide solutions is favoured thermodynamically (see Figure 4), one would not (in view of the high hydrogen over-voltage of zinc) expect significant quantities of the gas to be formed. That hydrogen is indeed evolved in observable quantities during cementation can be explained by the fact that the deposition of gold provides a cathodic surface with a very much lower over-potential; and it is from the gold surface that the hydrogen evolution takes place.

Many of the common constituents of gold cyanidation solutions influence the cementation reaction. Calcium sulphate tends to precipitate on the zinc and deactivate it. In the absence of sulphate, calcium ions appear to have a beneficial effect on the recovery⁶³. Sulphate, sulphite, thiosulphate, and ferrocyanide ions have a slightly depressing effect. They reduce the recovery by one or two per cent when present in concentrations of 10^{-3} to 10^{-2} M in 10^{-3} M cyanide solutions. Much more serious are the effects of sodium sulphide, copper cyanides, and arsenic and antimony compounds^{63,72}. They reduce the recovery significantly when they are present in concentrations of about 10^{-5} to 10^{-6} M. The extent of the reduction increases progressively with the concentration, until cementation ceases altogether. The concentrations at which this happens are given as^{63,72}:

Sulphide	4.5×10^{-4} M
Copper cyanide	6×10^{-5} M
Antimony	1.65×10^{-4} M
Arsenic	2.3×10^{-4} M

Little is known of the mechanism of these effects. The great sensitivity of both cyanidation and cementation to

the presence of sulphide suggests that a similar mechanism may be involved, and that sulphide may have a specific retarding effect on the anodic dissolution of zinc. The deleterious action of copper decreases as the concentration of cyanide increases. Although it has been shown that the presence of copper deposits at the zinc surface is not sufficient to account for the observed behaviour⁷³, no satisfactory alternative mechanism has been proposed.

What is known of the chemistry of cementation shows the surface area of the zinc precipitant to be one of the most important variables in the system. If it is borne in mind that the specific surface area of a typical zinc dust is some 500 times as great as that of typical shavings^{*}, it becomes clear why the substitution of zinc dust for shavings represented such an important advance in cementation technology. The cementation reaction is diffusion-controlled. Thus (see equation 26), under otherwise identical conditions the rate of cementation by dust should be hundreds of times greater than that by shavings. Furthermore, since most inhibitors act by forming barriers at the surface, their effects can be reduced by increasing the surface area. On the other hand, the rate of wasteful dissolution of zinc by side reactions such as equations 24 and 25, will also increase with the surface area. For this reason it is essential that when zinc dust is used, steps should be taken to reduce the extent of these reactions—hence, the importance of de-aeration of solutions, and of minimizing the time of contact between the solution and the zinc.

CEMENTATION BY ALUMINIUM

The use of metallic aluminium as a precipitant for gold and silver from cyanide solution was first proposed in 1893. Although the process has several attractive features, its use has never been widespread. It was thought to be more effective for the recovery of silver than of gold, and, indeed, that the precipitation of gold is incomplete unless substantial concentrations of silver are present. However, the only clear evidence on the point⁷⁴ indicates that gold is precipitated very efficiently even in the absence of silver, as long as the solution is de-aerated.

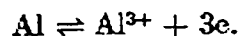
The attractive features of precipitation on aluminium are the following:

* Wartenweiler⁷⁵ calculated the geometric surface area of a typical dust to be 2.3 m²/g. Zinc shavings of thickness 7.62×10^{-4} cm (0.003 in) have a corresponding surface area of 87 cm²/g.

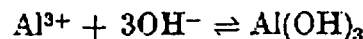
1. The cyanide content of the solution is regenerated. Unlike zinc, the aluminium that dissolves during the process does not combine with cyanide.

2. Most of the constituents of "foul" cyanide solutions that interfere with the zinc process are without effect on aluminium precipitation.

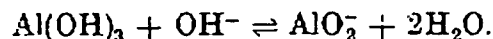
In essence, cementation by aluminium takes place by a mechanism similar to that of precipitation on zinc. The aurous cyanide takes up an electron at a cathodic site on the aluminium surface, and is reduced to gold metal. At the anodic sites, aluminium is oxidized



In alkaline solution



and



Since the soluble aluminate forms in preference to the insoluble hydroxide under a wide variety of conditions, the reaction proceeds unhindered by the formation of surface films.

Aluminium does not form strong bonds with sulphur, arsenic, and antimony. Thus, its compounds with these elements tend to dissociate in contact with water with the formation of Al^{3+} , $\text{Al}(\text{OH})_3$, or AlO_2^- , depending on the pH and concentration of aluminium. It is probable that the resistance of aluminium to poisoning by these elements is due to this property.

PRECIPITATION BY SOLUBLE REDUCING REAGENTS

Soluble reagents such as hydrogen sulphide, sulphur dioxide, sodium sulphite, and ferrous sulphate have been used industrially to precipitate gold from chloride solutions. Hydrogen sulphite precipitates gold as the auric sulphide, the others reduce it to the metal. The reasons for their ability to precipitate gold from chloride and not from cyanide solutions have been referred to earlier in this chapter.

Reductive precipitation proceeds without difficulty and gives essentially complete recoveries very rapidly. Thus there has been little incentive to study the mechanism of the reactions.

Although none of the other metallic chlorides found in typical chlorination solutions is precipitated by the reductive precipitants, the precipitated gold may be contaminated by significant concentrations of copper, silver, and iron. However, such contaminants can be removed by relatively simple procedures. Copper, and to a lesser extent, silver can be washed out of the precipitate by solutions containing ammonium ion. Iron is removed by washing with acid followed by smelting with a borax-based flux containing an oxidant such as manganese dioxide^{49, 50}. It is not certain in what form the contaminants are present, and their behaviour towards the solutions used to remove them shows many puzzling features.

ION EXCHANGE AND SOLVENT EXTRACTION

Ion exchange and solvent extraction techniques have been introduced into hydrometallurgy within the last two decades. They are used for recovering metallic ions from aqueous solutions, and simultaneously concentrating them and separating them from contaminants. Both techniques entail the transfer of the ion to and from a second phase: first the ion is transferred selectively from the leach liquor to the second phase, then it is returned to a reduced volume of fresh aqueous solution from which it can be precipitated more economically and in a higher state of purity. In ion exchange the second phase is an organic polymer, in solvent extraction it is a water-immiscible liquid. It is claimed that, with suitable design, both ion exchange and solvent extraction are more effective than the zinc cementation process for the treatment of highly contaminated solutions. In principle both techniques can be applied direct to pulps (the "resin-in-pulp" and "solvent-in-pulp" processes), thereby enabling the costly filtration stage to be dispensed with and the attendant losses of soluble values in the filter cakes to be eliminated. At the time of writing, the resin-in-pulp process is being seriously considered for the recovery of gold from cyanidation solution. Indeed, it has been designated the preferred technique for use in new plants in the Soviet Union⁷⁵.

The chemistry of these processes is complex and can be treated here only in the barest outline. For further details, the reader is referred to works devoted specifically to these subjects^{76, 77}.

To: Martin Quick
From: Paul Chamberlin
Date: 3/23/93

Assumption -
spray above the net.

Spray to Evaporate Sol'n @ Gilt Edge

Rate of Evaporation

- ~5% of the sol'n sprayed ^{in April}; this is a consensus & cannot be calculated or proved. It will be ~10% in summer months.
- Evap = 1.3 MM gal/mo in April; 15 hr/d.
= 2.2 MM " " ; 24 hr/d.
= 2.6 MM " " July; 15 hr/d
= 4.4 MM " " ; 24 hr/d

Cost

- ~ \$20,000 plus power for extra pump plus on-site installation labor.

Cautions

- - Layouts & costs need more detail.
- Uses up spare equipment on-site.

COST

- Approx. cost

Equipment

HDPE header, 810', SDR 15.5, 6" \varnothing , \$3.26/ft	\$2,641.
" elbow, 90°, 6" \varnothing , 1 ea.	67.
" caps, 2 ea, 6" \varnothing	93.
" tee, 6" \varnothing , 1 ea	85.
Valves, 6" \varnothing , 2 ea	600.
Flange adapters for valves	684.
PVC pipe, 20', 1" \varnothing , heavy wall	8.
" nipples, 20 ea	8.
" valves, ball, 1", 20 ea	480.
Spray heads, Bete #TF48NN, polypropylene, 20 each, 1", 60° spread	800.
Casing from submersible pump to #2" ON pump	400.
Power modifications, per Keith. <u>Check</u> →	7,000.-?
	<hr/>
	\$12,866.

Rent crane to set submersible pump + casing, 2 days ^{1600 gpm @ 0 psi g} \$2,500?

Installation, on-site people

- 0 -

Contingency, 25%

\$3,600.

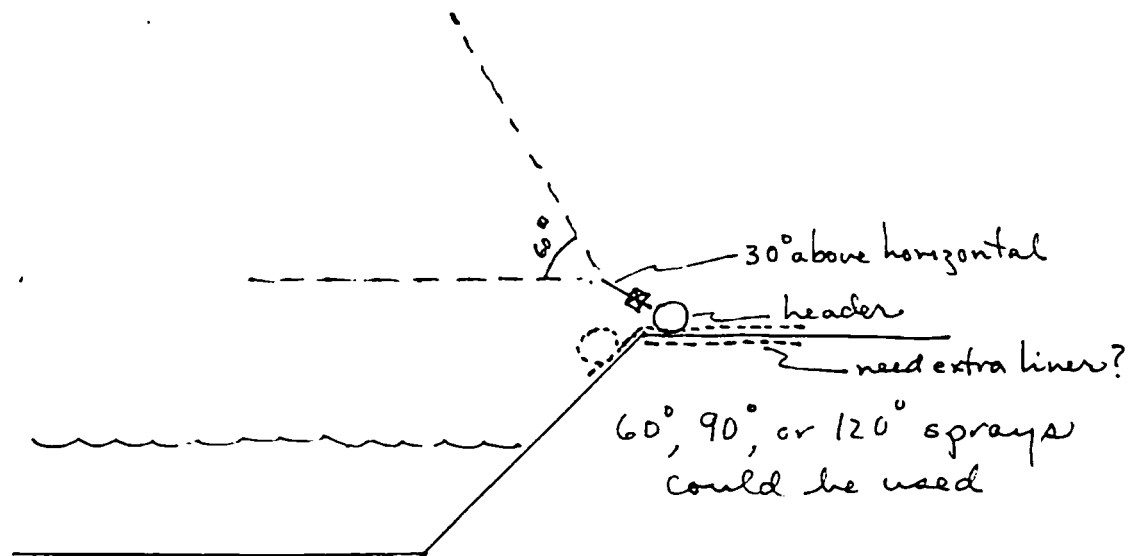
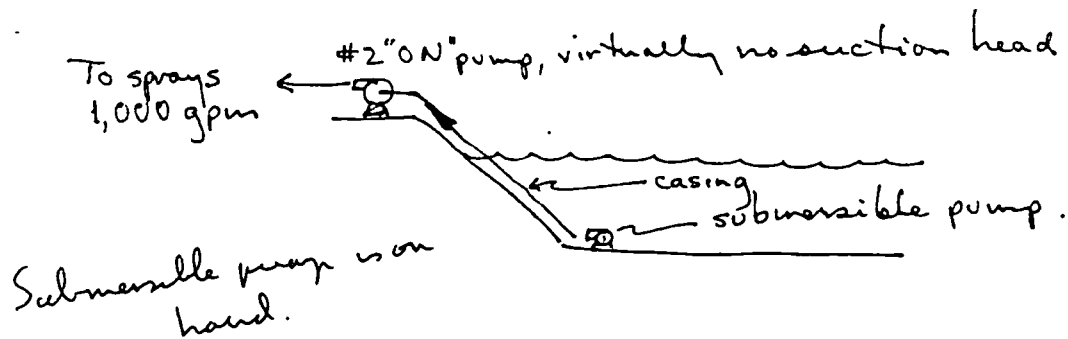
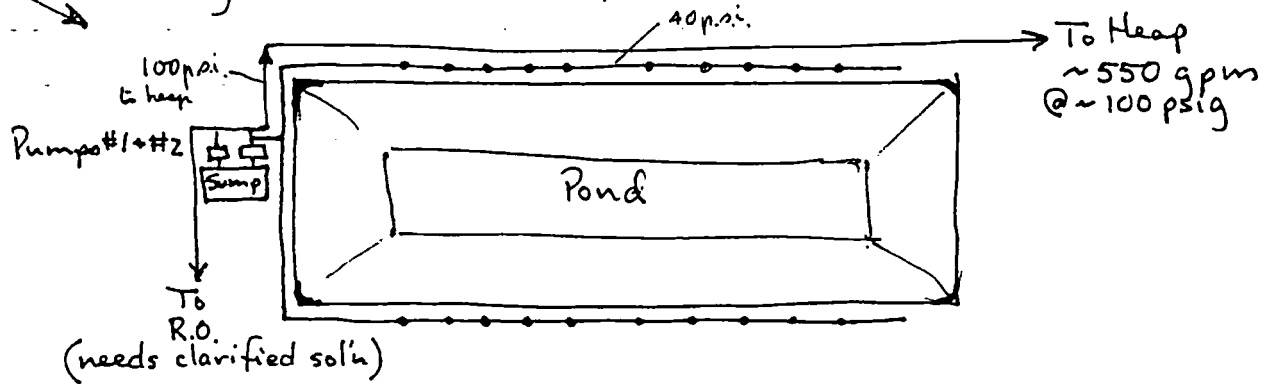
~ TOTAL

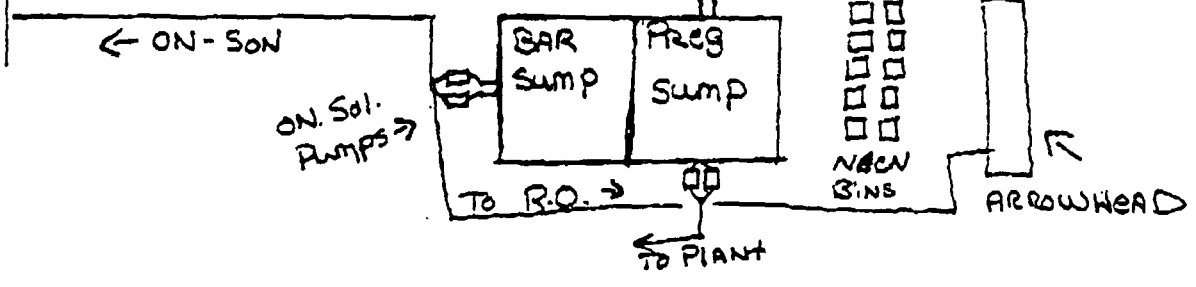
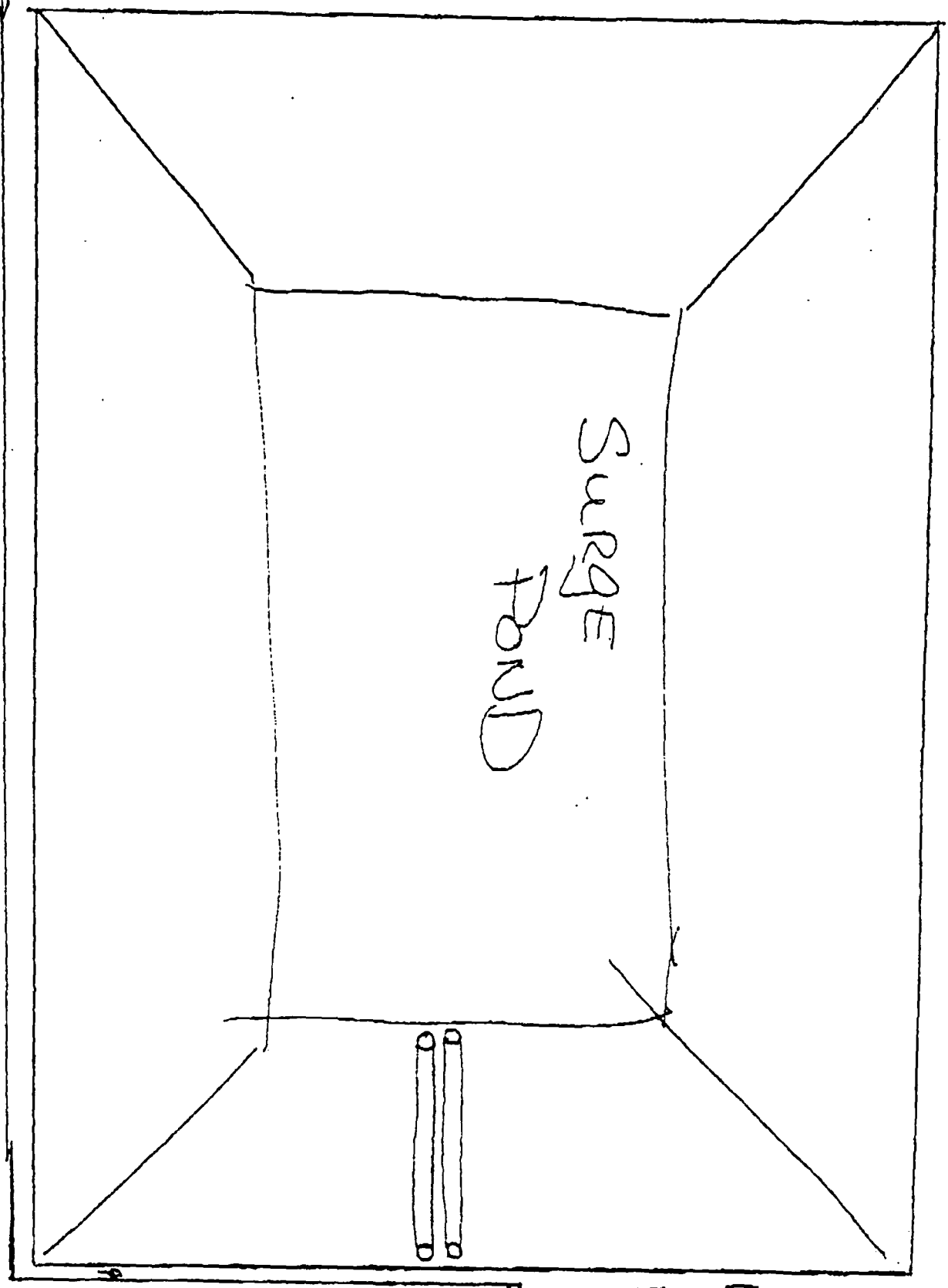
\$19,000.

Physical Layout

Prevailing winds.

~ N.





Physical Facilities

Electrical Power

Apparently there's not enough power available to run the two "ON" pumps and the R.O. unit. The power would be available for \$7,000 (per Keith).

Pumps

Two "ON" pumps ~~to~~ were installed to assure continuous flow to the heaps. If the flow of "ON" stops, the heaps will drain down and overflow the pond.

With spraying, both "ON" pumps would be in use, one to heap & other to sprays. If flow to heap stops due to pump failure, the pump to sprays must be switched to feed the heaps. That's OK.

The R.O. unit ~~must~~ must have clarified solution as feed. It should not be fed with solution from the pond. The sprays can be fed with unclarified pond water.

Notes:

- Spray spacing to prevent overlap
 - 60° cone @ 25' centers
 - 90° " @ 50' "
 - 120° " @ 75' "

The physical layout shows 60° sprays on 25' centers, i.e., 10 sprays on each side of pond.

- Spray size

Given that 1,000 gpm must be sprayed and that smaller sprays give smaller droplet size, and that ~40 psig was the most pressure to be expected, it was decided to use 10 sprays on each side of pond. The wind may dictate that sprays on only one side of pond can be used.

From Bete catalog, the TF48NN sprays 95 gpm @ 40 psig. Ten of these can be fit within the pond without much fear of overspray (drift) or overlapping.

- Rate of evaporation

There are no exact ways of estimating how much of the sprayed H₂O will evaporate.

A theoretical equation that takes into account only H₂O temperature, wet bulb temperature, and an efficiency factor is:

Notes, con't.

$$(H_2O\ ^\circ F - \text{wet bulb } ^\circ F) \times \frac{1\% \text{ evap}}{10^\circ F} \times 0.7 \text{ cooling efficiency} =$$

% of sprayed H_2O that is evaporated.

This formula gives very low evap. values because it doesn't acc't. for wind velocity, relative velocity between air & droplet, etc.

Actual estimates from operating mines are:

- Richmond Hill, 20% annual average.
- Summitville, 13% in March weather.
- San Luis, 21% in hot summer months.

After talking with these operators, they estimated that ~ 5% of sprayed H_2O would be evaporated @ Gilt Edge. In contrast, the formula says about 1%. These are values for April. Each succeeding month gets better.

- Oversaturation

If sprays overlap (and even if they don't), it is easy to oversaturate the air. If this happens, evaporation stops.

Notes, con't.

- Trajectory

The sprays will have a trajectory of 10' to 50', depending on spray head angle, wind velocity, and H_2O pressure.

- Droplet average size ≈ 500 microns
 ≈ 35 mesh.

Hollow cone sprays \rightarrow smaller droplets, $\sim 10\%$ smaller, than full cone sprays, all else being equal.

- Flowrate

To replace an R.O. unit, the spray system will need to evaporate 50 gpm. Given a 5% evap. rate, the gpm to be sprayed must be 1000 gpm.

$$50 \text{ gpm} = 5\% \times 1000 \text{ gpm.}$$

If sprays operate only during daylight hours (to keep an eye on spray drift), spraying may be done only 15 hours/day.

The amount of H_2O evaporated per month will be:

$$50 \text{ gpm} \times 1440 \frac{\text{min}}{\text{d}} \times \frac{30 \text{ d}}{\text{mo}} \times \frac{15 \text{ hr}}{24 \text{ hr}} = 1,350,000 \text{ gal/mo}$$

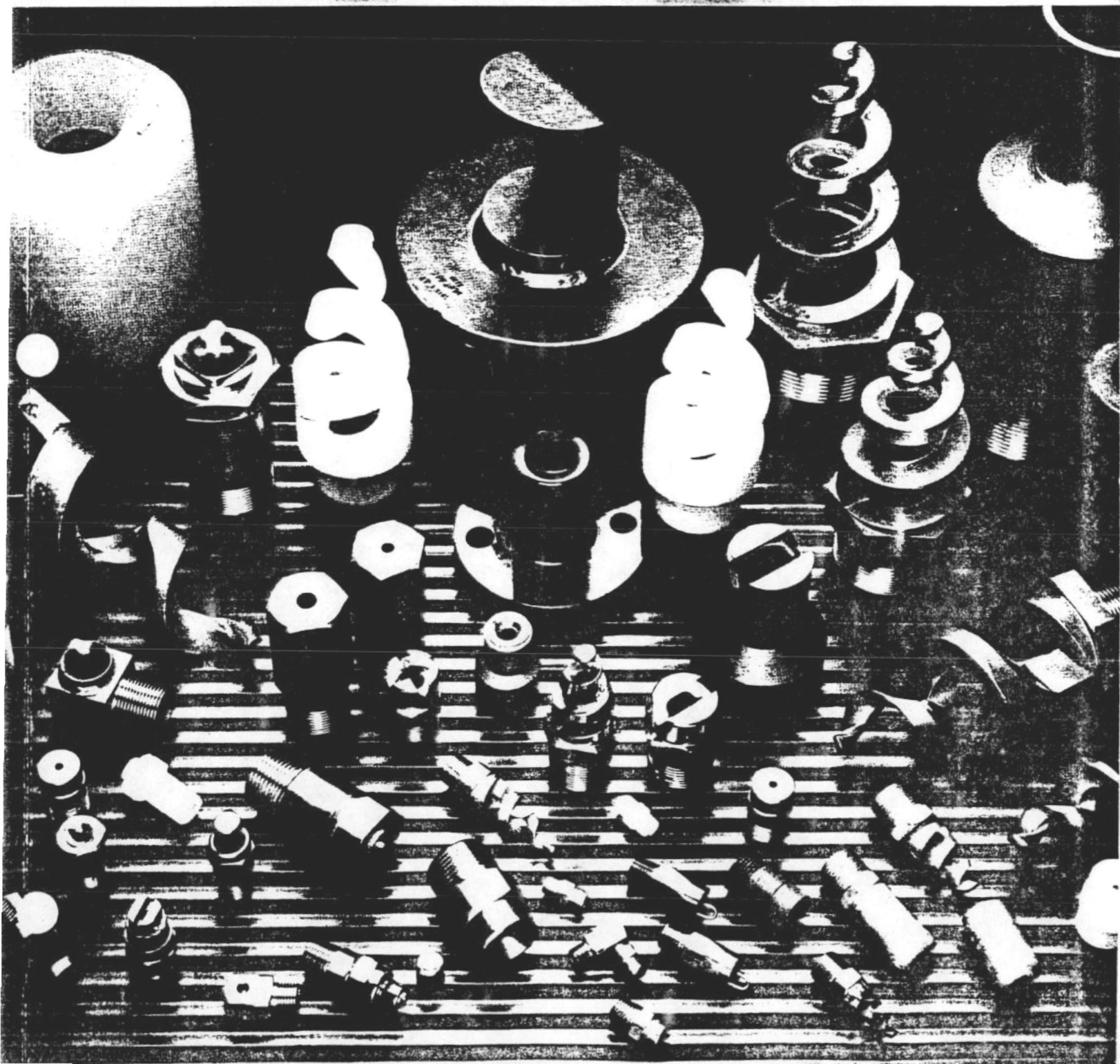
$$\text{@ 24 hr/day of spraying, it will be} = 2,160,000 \text{ gal/mo}$$

Daniel deLesdernier
1-800-235-0049
in MA.

BETE
FOG
NOZZLE
INC.



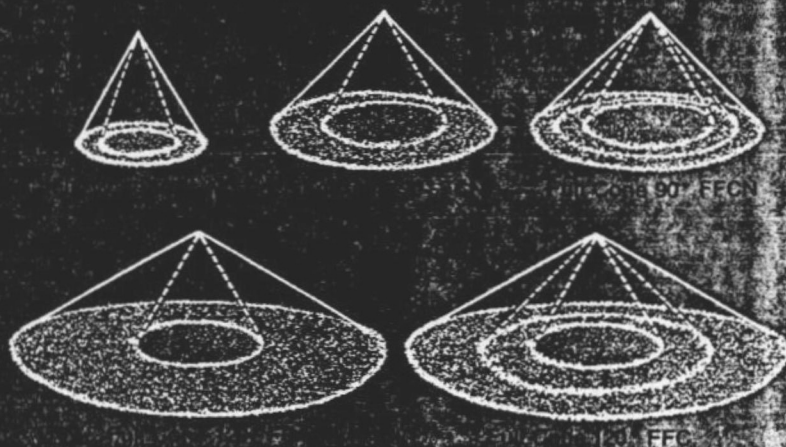
NOZZLES FOR INDUSTRY, POLLUTION CONTROL AND FIRE PROTECTION



TF

Standard Line
Wide Range of Flow
Angles and Materials
Full and Hollow Cone

Spiral



DESIGN

Unique Bete spiral nozzles
solve many difficult spray problems
HIGH ENERGY EFFICIENCY
One piece - no internal parts
Clog-free performance
High discharge velocity

SPRAY CHARACTERISTICS

Wide range of flow rates and spray angles
Fine atomization
Spray patterns - full and hollow cone
Spray angles - 50° to 120°
Flow rates - .7 to 3350 gpm
Higher flow rates available

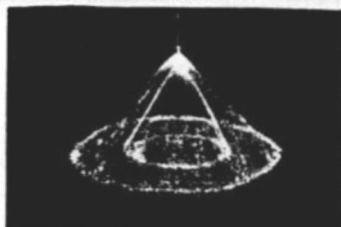
FULL CONE 60° Full Cone available in metals only.

Spray Angle	Male Pipe Size	Nozzle Number	Orifice Dia.	Free Passage Dia.	Overall Length	Hex. or Round Dia.	Weight Plastic Oz.	Metal Oz.	GALLONS PER MINUTE @ PSI									
									10	20	30	40	50	60	80	100	200*	400*
60°	1/4	TF6NN	3/32	3/32	1 7/8	3/4		1	.7	1.0	1.2	1.4	1.6	1.7	2.0	2.2	3.1	4.4
		TF8NN	1/8	1/8	1 7/8	3/4		1	1.3	1.9	2.3	2.6	2.9	3.2	3.8	4.1	6.0	8.2
		TF10NN	5/32	1/8	1 7/8	3/4		1	2.0	2.9	3.5	4.0	4.5	5.0	5.9	6.5	9.2	13.0
	3/8	TF6NN	3/32	3/32	1 7/8	3/4		1	.7	1.0	1.2	1.4	1.6	1.7	2.0	2.2	3.1	4.4
		TF8NN	1/8	1/8	1 7/8	3/4		1	1.3	1.9	2.3	2.6	2.9	3.2	3.8	4.1	6.0	8.2
		TF10NN	5/32	1/8	1 7/8	3/4		1	2.0	2.9	3.5	4.0	4.5	5.0	5.9	6.5	9.2	13.0
		TF12NN	3/16	1/8	1 7/8	3/4		1 1/2	3.0	4.2	5.2	6.0	6.7	7.4	8.5	9.5	13.4	19
		TF14NN	7/32	1/8	1 7/8	3/4		1 1/2	4.0	5.7	7.0	8.1	9.0	10.0	11.4	12.5	18	25
		TF16NN	1/4	1/8	1 7/8	3/4		1 1/2	5.3	7.5	9.2	10.6	11.8	13.0	15.0	16.7	24	33
		TF20NN	5/16	1/8	1 7/8	3/4		1 1/2	8.2	11.7	14.3	16.5	18.4	20.0	23.3	26.1	36	52
	1/2	TF24NN	3/8	3/16	2 1/2	7/8		2 3/4	12.0	17.0	20.8	24.1	26.6	29.4	34	38	54	76
		TF28NN	7/16	3/16	2 1/2	7/8		2 3/4	16.4	23	28	33	37	40	46	52	74	104
	3/4	TF32NN	1/2	3/16	2 3/4	1 1/8		4 1/2	21	30	37	42	47	52	60	67	94	134
	1 1/2	TF40NN	5/8	1/4	3 5/8	1 3/8		7 1/2	34	48	57	67	74	81	94	105	148	210
		TF48NN	3/4	1/4	3 5/8	1 3/8		7 1/2	47	67	83	95	107	117	135	151	214	302
		TF56NN	7/8	5/16	4 3/8	2		21	64	93	112	129	145	159	184	205	290	410
90°	1/8	TF6FCN	3/32	3/32	1 11/16	3/4	1/2	1	.7	1.0	1.2	1.4	1.6	1.7	2.0	2.2	3.1	4.4
		TF8FCN	1/8	1/8	1 11/16	3/4	1/2	1	1.3	1.9	2.3	2.6	2.9	3.2	3.8	4.1	6.0	8.2
	1/4	TF6FCN	3/32	3/32	1 7/8	3/4	1/2	1	.7	1.0	1.2	1.4	1.6	1.7	2.0	2.2	3.1	4.4
		TF8FCN	1/8	1/8	1 7/8	3/4	1/2	1	1.3	1.9	2.3	2.6	2.9	3.2	3.8	4.1	6.0	8.2
		TF10FCN	5/32	1/8	1 7/8	3/4	1/2	1	2.0	2.9	3.5	4.0	4.5	5.0	5.9	6.5	9.2	13.0
	3/8	TF12FCN	3/16	1/8	1 7/8	3/4	3/4	1 1/2	3.0	4.2	5.2	6.0	6.7	7.4	8.5	9.5	13.4	19
		TF14FCN	7/32	1/8	1 7/8	3/4	3/4	1 1/2	4.0	5.7	7.0	8.1	9.0	10.0	11.4	12.5	18	25
		TF16FCN	1/4	1/8	1 7/8	3/4	3/4	1 1/2	5.3	7.5	9.2	10.6	11.8	13.0	15.0	16.7	24	33
		TF20FCN	5/16	1/8	1 7/8	3/4	3/4	1 1/2	8.2	11.7	14.3	16.5	18.4	20.0	23.3	26.1	36	52
	1/2	TF24FCN	3/8	3/16	2 1/2	7/8	1	2 3/4	12.0	17.0	20.8	24.1	26.6	29.4	34	38	54	76
		TF28FCN	7/16	3/16	2 1/2	7/8	1	2 3/4	16.4	23	28	33	37	40	46	52	74	104
	3/4	TF32FCN	1/2	3/16	2 3/4	1 1/8	1 1/2	4 1/2	21	30	37	42	47	52	60	67	94	134
	1	TF40FCN	5/8	1/4	3 5/8	1 3/8	2 1/2	7 1/2	34	48	57	67	74	81	94	105	148	210
		TF48FCN	3/4	1/4	3 5/8	1 3/8	2 1/2	7 1/2	47	67	83	95	107	117	135	151	214	302
	1 1/2	TF56FCN	7/8	5/16	4 3/8	2	5 1/2	21	64	93	112	129	145	159	184	205	290	410
		TF64FCN	1	5/16	4 3/8	2	5 1/2	21	84	120	147	169	190	208	240	268	380	536
	2	TF72FCN	1 1/8	5/16	4 3/8	2	5 1/2	21	96	137	165	192	213	235	270	302	426	604
		TF88FCN	1 3/8	7/16	5 7/8	2 1/2	6 1/2	26	140	198	240	280	310	340	395	438	620	876
	3	TF96FFCN	1 1/2	7/16	6 7/8	2 1/2	7 1/2	32	178	250	310	355	395	430	505	560	790	1120
		TF112FFCN	1 3/4	9/16	8	3 1/2	26	104	256	362	448	516	580	636	736	810	1160	1720
	4	TF128FFCN	2	9/16	8	3 1/2	26	104	336	480	588	676	760	832	960	1072	1520	2140
		TF160FFCN	2 1/2	5/8	9	4 1/2	40	160	525	750	920	1058	1188	1300	1500	1675	2370	3350

For adapters and bushings, refer to Accessories page

* High pressure operation recommended for metal nozzles only.

† Plastic length: 3 5/8" ‡ Plastic length: 4 3/8"



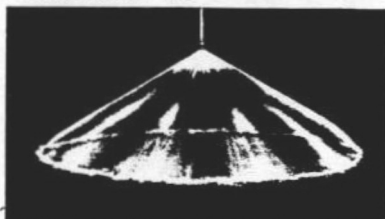
Full Cone 90° FCN



Full Cone 120° FC



Hollow Cone 50° N



Hollow Cone 120° W

MATERIALS

PVC
Polypropylene
Teflon
Brass
303 Stainless Steel
316 Stainless Steel
C-20
Hastelloy C
Inconel 625
Incoloy
Tantalum
Titanium
Other materials
on application

TYPICAL APPLICATIONS

Chemical processing
Cooling gases
Deaerating
Dry powder systems
Dust removal
Evaporative cooling
Evaporative disposal
Fixed fire protection
Halon systems
Scrubbers - air, gas, SO₂
Snow making
Spray absorption
Spray ponds
Tank rinsing
Water purification

*~ 10% finer drop size than full cone
even the gpm of both is the same.*

FULL CONE

Spray Angle	Male Pipe Size	Nozzle Number	Orifice Dia.	Free Passage Dia.	Overall Length	Hex. or Round Dia.	Plastic Oz.	Weight Metal Oz.	GALLONS PER MINUTE @ PSI										
									10	20	30	40	50	60	80	100	200*	400*	
120°	1/8	TF6FC	3/32	3/32	1 11/16	3/4	1/2	1	.7	1.0	1.2	1.4	1.6	1.7	2.0	2.2	3.1	4.4	
		TF8FC	1/8	1/8	1 11/16	3/4	1/2	1	1.3	1.9	2.3	2.6	2.9	3.2	3.8	4.1	6.0	8.2	
	1/4	TF6FC	3/32	3/32	1 7/8	3/4	1/2	1	.7	1.0	1.2	1.4	1.6	1.7	2.0	2.2	3.1	4.4	
		TF8FC	1/8	1/8	1 7/8	3/4	1/2	1	1.3	1.9	2.3	2.6	2.9	3.2	3.8	4.1	6.0	8.2	
		TF10FC	5/32	1/8	1 7/8	3/4	1/2	1	2.0	2.9	3.5	4.0	4.5	5.0	5.9	6.5	9.2	13.0	
	3/8	TF12FC	3/16	1/8	1 7/8	3/4	3/4	1 1/2	3.0	4.2	5.2	6.0	6.7	7.4	8.5	9.5	13.4	19	
		TF14FC	7/32	1/8	1 7/8	3/4	3/4	1 1/2	4.0	5.7	7.0	8.1	9.0	10.0	11.4	12.5	18	25	
		TF16FC	1/4	1/8	1 7/8	3/4	3/4	1 1/2	5.3	7.5	9.2	10.6	11.8	13.0	15.0	16.7	24	33	
		TF20FC	5/16	1/8	1 7/8	3/4	3/4	1 1/2	8.2	11.7	14.3	16.5	18.4	20.0	23.3	26.1	36	52	
	1/2	TF24FC	3/8	3/16	2 1/2	7/8	1	2 3/4	12.0	17.0	20.8	24.1	26.8	29.4	34	38	54	76	
		TF28FC	7/16	3/16	2 1/2	7/8	1	2 3/4	16.4	23	28	33	37	40	46	52	74	104	
	3/4	TF32FC	1/2	3/16	2 3/4 †	1 1/8	1 1/2	4 1/2	21	30	37	42	47	52	60	67	94	134	
	1	TF40FC	5/8	1/4	3 5/8 ‡	1 3/8	2 1/2	7 1/2	34	48	57	67	74	81	94	105	148	210	
		TF48FC	3/4	1/4	3 5/8 ‡	1 3/8	2 1/2	7 1/2	47	67	83	95	107	117	135	151	214	302	
	1 1/2	TF56FC	7/8	5/16	4 3/8	2	5 1/2	21	64	93	112	129	145	159	184	205	290	410	
		TF64FC	1	5/16	4 3/8	2	5 1/2	21	84	120	147	169	190	208	240	268	380	536	
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	TF96FFC	1 1/2	7/16	6 7/8	2 1/2	7 1/2	32	178	250	310	355	395	430	505	560	790	1120		
3	TF112FFC	1 3/4	9/16	8	3 1/2	26	104	256	362	448	516	580	636	736	810	1160	1720		
	TF128FFC	2	9/16	8	3 1/2	26	104	336	480	588	676	760	832	960	1072	1520	2140		
4	TF160FFC	2 1/2	5/8	9	4 1/2	40	160	525	750	920	1058	1188	1300	1500	1675	2370	3350		

HOLLOW CONE

Spray Angle	Male Pipe Size	Nozzle Number	Orifice Dia.	Free Passage Dia.	Overall Length	Hex. or Round Dia.	Weight		GALLONS PER MINUTE @ PSI									
							Plastic Oz.	Metal O:	10	20	30	40	50	60	80	100	200**	400**
50°	1/4	TF6N	3/32	3/32	1 7/8	3/4	1/2	1	.7	1.0	1.2	1.4	1.6	1.7	2.0	2.2	3.1	4.4
		TF8N	1/8	1/8	1 7/8	3/4	1/2	1	1.3	1.9	2.3	2.6	2.9	3.2	3.8	4.1	6.0	8.2
		TF10N	5/32	1/8	1 7/8	3/4	1/2	1	2.0	2.9	3.5	4.0	4.5	5.0	5.9	6.5	9.2	13.0
	3/8	TF12N	3/16	1/8	1 7/8	3/4	3/4	1 1/2	3.0	4.2	5.2	6.0	6.7	7.4	8.5	9.5	13.4	19
		TF14N	7/32	1/8	1 7/8	3/4	3/4	1 1/2	4.0	5.7	7.0	8.1	9.0	10.0	11.4	12.5	18	25
		TF16N	1/4	1/8	1 7/8	3/4	3/4	1 1/2	5.3	7.5	9.2	10.6	11.8	13.0	15.0	16.7	24	33
		TF20N	5/16	1/8	1 7/8	3/4	3/4	1 1/2	8.2	11.7	14.3	16.5	18.4	20.0	23.3	26.1	36	52
	1/2	TF24N	3/8	3/16	2 1/2	7/8	1	2 3/4	12.0	17.0	20.8	24.1	26.8	29.4	34	38	54	76
		TF28N	7/16	3/16	2 1/2	7/8	1	2 3/4	16.4	23	28	33	37	40	46	52	74	104
	3/4	TF32N	1/2	3/16	2 3/4 †	1 1/8	1 1/2	4 1/2	21	30	37	42	47	52	60	67	94	134
120°	1/4	TF6W	3/32	3/32	1 3/4	5/8	1/2	1	.7	1.0	1.2	1.4	1.6	1.7	2.0	2.2	3.1	4.4
		TF8W	1/8	1/8	1 3/4	5/8	1/2	1	1.3	1.9	2.3	2.6	2.9	3.2	3.8	4.1	6.0	8.2
		TF10W	5/32	1/8	1 3/4	5/8	1/2	1	2.0	2.9	3.5	4.0	4.5	5.0	5.9	6.5	9.2	13.0
	3/8	TF12W	3/16	1/8	1 7/8	3/4	3/4	1 1/2	3.0	4.2	5.2	6.0	6.7	7.4	8.5	9.5	13.4	19
		TF14W	7/32	1/8	1 7/8	3/4	3/4	1 1/2	4.0	5.7	7.0	8.1	9.0	10.0	11.4	12.5	18	25
		TF16W	1/4	1/8	1 7/8	3/4	3/4	1 1/2	5.3	7.5	9.2	10.6	11.8	13.0	15.0	16.7*	24	33
		TF20W	5/16	1/8	1 7/8	3/4	3/4	1 1/2	8.2	11.7	14.3	16.5	18.4	20.0	23.3	26.1	36	52
	1/2	TF24W	3/8	3/16	2 1/2	7/8	1	2 3/4	12.0	17.0	20.8	24.1	26.8	29.4	34	38	54	76
		TF28W	7/16	3/16	2 1/2	7/8	1	2 3/4	16.4	23	28	33	37	40	46	52	74	104
	3/4	TF32W	1/2	3/16	2 3/4 †	1 1/8	1 1/2	4 1/2	21	30	37	42	47	52	60	67	94	134

For adapters and bushings, refer to Accessories page

TO ORDER: Specify Spray Angle, Pipe Size, Nozzle Number and Material

*High pressure operation recommended for metal nozzles only.

†Plastic length: 3 5/8" ‡Plastic length: 4 3/8"

BETE FOG NOZZLE INC.

BETE Fog Nozzle, Inc.

Technical Services Department

FAX:(413) 772-6729

Telephone:(413) 772-0846

ATTN: Daniel deLesdernier

To: Paul Chamberlin
Address: Chamberlin & Assoc.
FAX No.: 303-979-6753
Your Ref: Evaporative Disposal
Our Ref: 930318

FAX File Ref: 3-1332-93

Date: March 22, 1993

Page: 1 Of: 2

Paul-

I talked to Steve at Richmond Hill who said that I should really have you call him directly.

From what other customers have told us, one can typically expect 5-10% of the sprayed volume to evaporate, although this depends greatly on temperature and humidity. In your case, where you need to be conservative to combat wind drift, I would say you want to be more on the 5% end of the spectrum. I have attached a page showing a typical spray pond layout. We recommend the TF series nozzles because they atomize more finely than other direct pressure nozzles. One normally tries to keep the patterns separated to prevent local saturation of the air that would inhibit evaporation.

If you mounted a series of nozzles along the sides of your pond you could use only the nozzles on the upwind side(s) to allow the spray to settle back onto the surface before it gets blown away. We can provide some limited help in estimating trajectories for droplets in a wind.

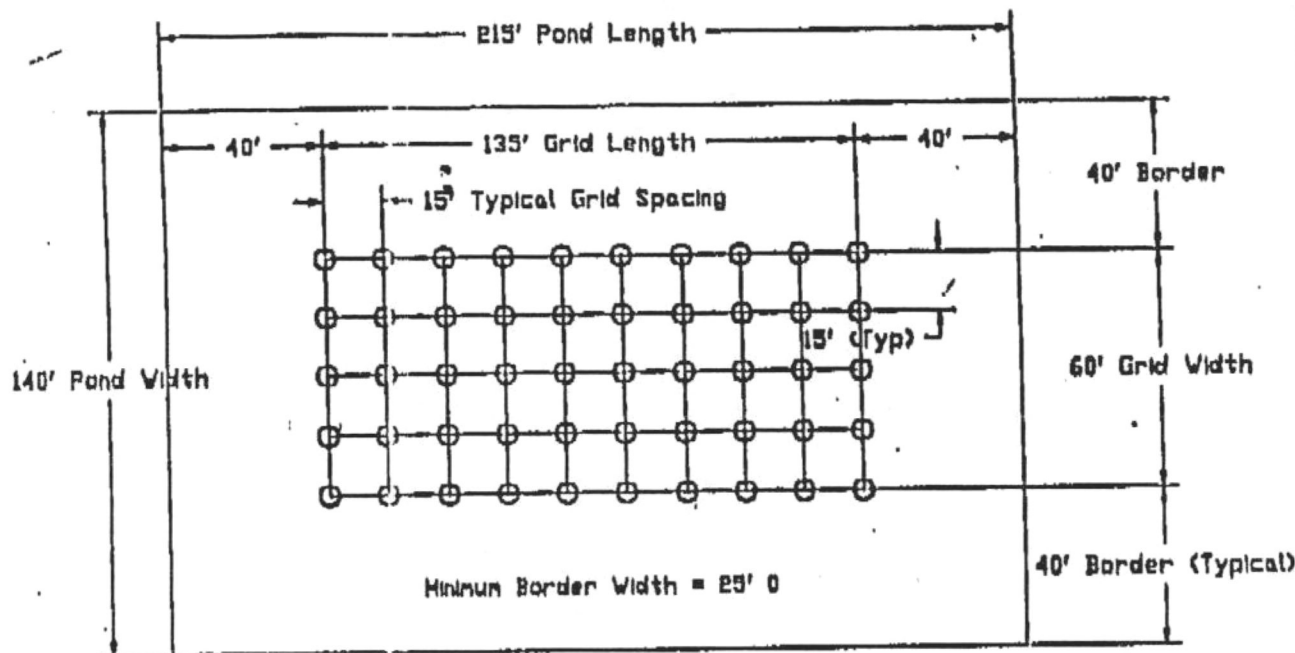
Operating pressures vary from perhaps 10 psi to perhaps 40 psi.

This should give you enough information to get started, but if you have further questions, I will try to help.

Regards,



Daniel deLesdernier



SUGGESTED SPRAY POND LAYOUT

FOR EVAPORATIVE DISPOSAL PONDS

SPRAY POND APPLICATION

• RECOMMENDED NOZZLE: 3/4 TF 32 XPN

- The nozzle should be oriented to spray vertically upward to gain maximum residence time for the droplets to evaporate. The 90 degree spray angle achieves maximum vertical projection into the less saturated air layers.
- By installing the nozzle 4 feet above the pond surface, more residence time can also be gained. The effect of wind speed on spray drift should be taken into consideration.
- The efficiency of a spray evaporation pond depends on environmental factors (geographic location, wind conditions), pond layout, number and spacing of nozzles, height of spray nozzles and liquid pressure.
- The pond layout should be rectangular (length = 2 to 4 times width) with the long side facing the prevailing wind direction.

- Spray droplet size also has a major effect on the amount of evaporation. The recommended operating pressure should be between 30 and 60 psi, with the higher pressures giving smaller droplet sizes.

The BETE Difference

The BETE Series gives the smallest droplet size of any direct pressure nozzle in order to take maximum advantage of the small droplet size, there must be a minimum of 10 feet spacing between adjacent spray patterns to allow for full evaporation.

In many applications the liquid being sprayed contains large solid particles that may plug the nozzle. The BETE TF XPN Series provides a large Free Passage equal to the orifice diameter. This feature allows for a lower maintenance operation.

BETE®

FROM: OJONCO Sales Company
 1425 East Bates Avenue, Englewood, CO 80110
 Phone/FAX: (303) 781-9145

Technical Services

CC:N594

zap fax!Customer: Mr. Paul ChamberlinCompany: Chamberlin & Assoc.

Reference: _____

Company Address: _____

Telephone: 303-979-6753FAX: 303-979-6753

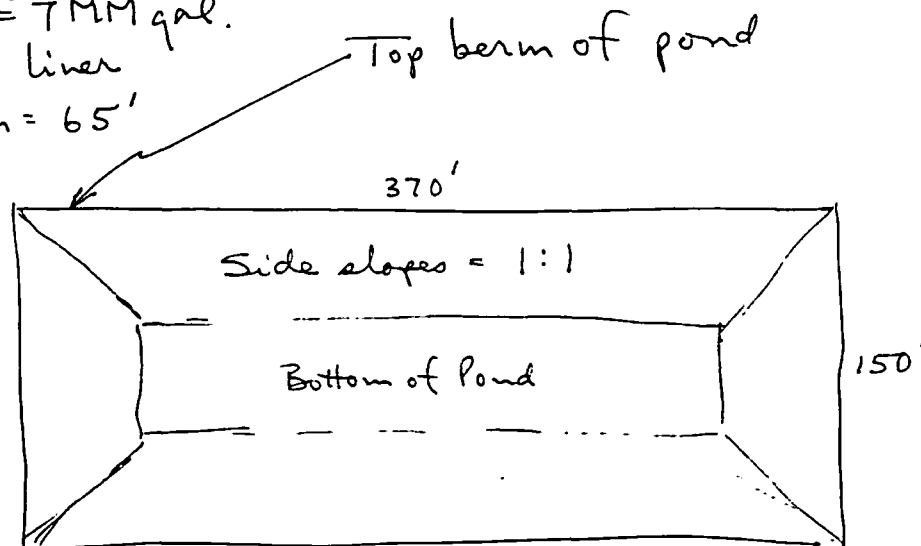
Briefly describe what the nozzle needs to do. If possible, include a sketch with dimensions (use a separate sheet, if necessary):

Evaporate H_2O quickly, 8MM gal in 2 mo.

Pond capacity \approx 7MM gal.

Pond has HDPE liner

Max. pond depth = 65'



Put sprays just inside top berm (on the HDPE); use both long sides or all 4 sides; no spray drift allowed!!
 Sol'n depth in pond may range from 15' to 65' deep depending on how full the pond is.

• What liquid is being sprayed?: Dilute gold leaching sol'n w/ 1,000 ppm cyanide

• How much liquid needs to be sprayed? in 2 months.
8,000,000 gal. evaporated? April + May
 total _____ per nozzle _____

• What liquid pressure is available?: up to 80 psig

• If the liquid isn't water, what's the specific gravity?: _____

• What nozzle materials are suitable? (If unsure about the nozzle material, what materials are used in the piping?): 304 SS or 316 SS.

Plastics if wear rate is low.

• Estimated number of nozzles required: _____

• Annually: _____

• Nozzles needed by (date): 4/1/93

Date: 3/16/93

Time: 2:51

Lori Burn 1-800-235-0049

MID-CONTINENT TESTING LABORATORIES, INC.

HIGH TECHNOLOGY OIL ANALYSIS
AND ENVIRONMENTAL TESTING



2381 S. Plaza Dr. • P.O. Box 3388 • Rapid City, SD 57709
(605) 348-0111

MYRON ANDERSEN
BROHM MINING CORP.
P.O. BOX 485
DEADWOOD, SD 57732

SAMPLE NAME: ON-SOL
DESCRIPTION:
SAMPLE DATE: 11/17/92
SAMPLE TIME:
SAMPLED BY:

ACCOUNT NUMBER: W1000
LAB NUMBER: 19921118102
DATE RECEIVED: 11/18/92
TIME RECEIVED: 08:00 AM
REPORT DATE: 11/20/92

FIELD FLOW = 85

PHYSICAL PROPERTIES	VALUE	METALS mg/l	DISSOLVED	TOTAL
Conductivity, umhos/cm	6390.	Aluminum	.013	.024
Hardness	2018.	Antimony	.	.
PH	9.83	Arsenic	.160	.164
Solids, Dissolved, mg/l	5405.	Barium	.	.
Solids, Suspended, mg/l	<10.0	Beryllium	.	.
Turbidity, NTU	.	Boron	.	.
		Cadmium	<.001	<.001
		Calcium	801.	.
		Chromium	.002	.003
		Cobalt	.	.
		Copper	104.	473.
		Gold	.	.
		Iron	.053	.098
		Lead	.001	.006
		Lithium	.	.
		Magnesium	4.34	.
		Manganese	<.050	.050
		Mercury	.	.0008
		Molybdenum	.	.
		Nickel	.	.
		Potassium	35.0	.
		Selenium	.109	.197
		Silicon	.	.
		Silver	.	.
		Sodium	738.	.
		Strontium	.	.
		Vanadium	.	.
		Zinc	20.3	23.8

INORGANIC & NONMETALLIC	VALUE
Alkalinity	966.
Bicarbonate	725.
Carbonate, mg/l	223.
Chloride, mg/l	325.
Cyanide, Total, mg/l	1162.
Cyanide, WAD, mg/l	1162.
Cyanide, Free, mg/l	1139.
Fluoride, mg/l	.
Nitrogen, Ammonia, mg/l	84.6
Nitrogen, Nitrate, mg/l	37.6
Nitrogen, Nitrite, mg/l	5.00
Sulfate, mg/l	1100.

SPECIAL TESTS	VALUE
FIELD PH	9.20
FIELD EC	2000.+
FIELD TEMP	13.0 C
SCN	144.

APPROVED BY:

DATE:

S. Schaefer
11/20/92

Per Rod MacLeod 3/16/93

36" snow = 3-4 MM gal

2 MM now in pond

11" rain in 2-3 mo. 6.5 MM rainfall

(-) $\Sigma \sim 13 \text{ MM}$
5 MM in pond

Get rid of $\rightarrow 8 \text{ MM}$ + heap drain down*

1 MM gal/cell = drain down
 ~ 18 cells (multi lifts) - all wet now

* this should not occur; in fact, use ~~heaps~~ ^{heaps} to max
for H₂O storage.